US009328962B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 9,328,962 B2**
(45) **Date of Patent:** **May 3, 2016**

(54) **APPARATUS AND METHODS TO OPERATE A MICROREACTOR**

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(73) Assignee: **Pharyx, Inc.**, Woburn, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 497 days.

(21) Appl. No.: **13/750,982**

(22) Filed: **Jan. 25, 2013**

(65) **Prior Publication Data**

US 2013/0196276 A1 Aug. 1, 2013

Related U.S. Application Data

(60) Provisional application No. 61/590,861, filed on Jan. 26, 2012.

(51) **Int. Cl.**

F27D 7/00	(2006.01)
C12M 3/06	(2006.01)
C12M 1/00	(2006.01)
C12M 1/02	(2006.01)
B01J 19/00	(2006.01)
B01L 3/00	(2006.01)
B01L 7/00	(2006.01)

(52) **U.S. Cl.**

CPC ***F27D 7/00*** (2013.01); ***B01J 19/0093*** (2013.01); ***B01L 3/502715*** (2013.01); ***B01L 7/00*** (2013.01); ***C12M 23/16*** (2013.01); ***C12M 29/14*** (2013.01); ***C12M 41/22*** (2013.01); *B01J 2219/0095* (2013.01); *B01J 2219/0097* (2013.01); *B01J 2219/00813* (2013.01); *B01J 2219/00817* (2013.01); *B01J 2219/00873* (2013.01); *B01J 2219/00961* (2013.01); *B01L 2200/027* (2013.01); *B01L 2300/043* (2013.01); *B01L 2300/0816* (2013.01); *B01L 2300/1805* (2013.01); *B01L 2400/0487* (2013.01); *Y10T 29/49826* (2015.01); *Y10T 29/53* (2015.01)

(58) **Field of Classification Search**

CPC B01L 9/527; B01L 2200/027

See application file for complete search history.

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Assistant Examiner — Matthew Krcha
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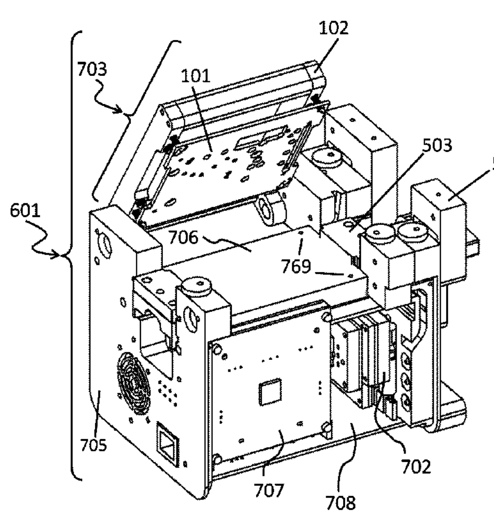
(57) **ABSTRACT**

The present invention provides apparatus and methods to operate microreactor devices through the controlled delivery of pressurized fluids. A heated reservoir, a heated manifold, and a heater for the microreactor device provides for the delivery of a pressurized gas while minimizing evaporation and condensation; and a fluid interface and pressure interlock provides for the delivery of aseptic fluids while minimizing contamination and fluid loss.

18 Claims, 15 Drawing Sheets



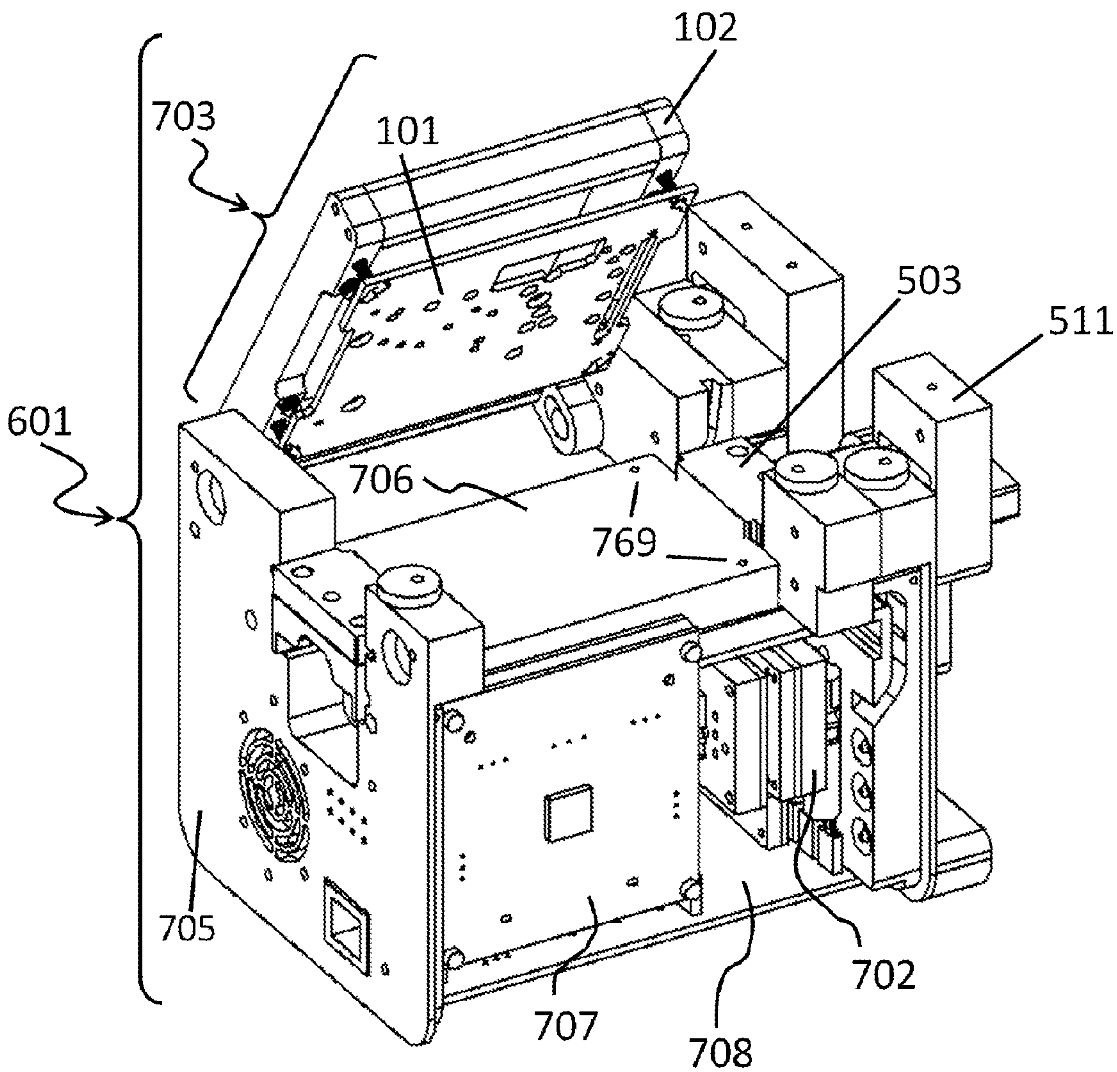


FIG. 1

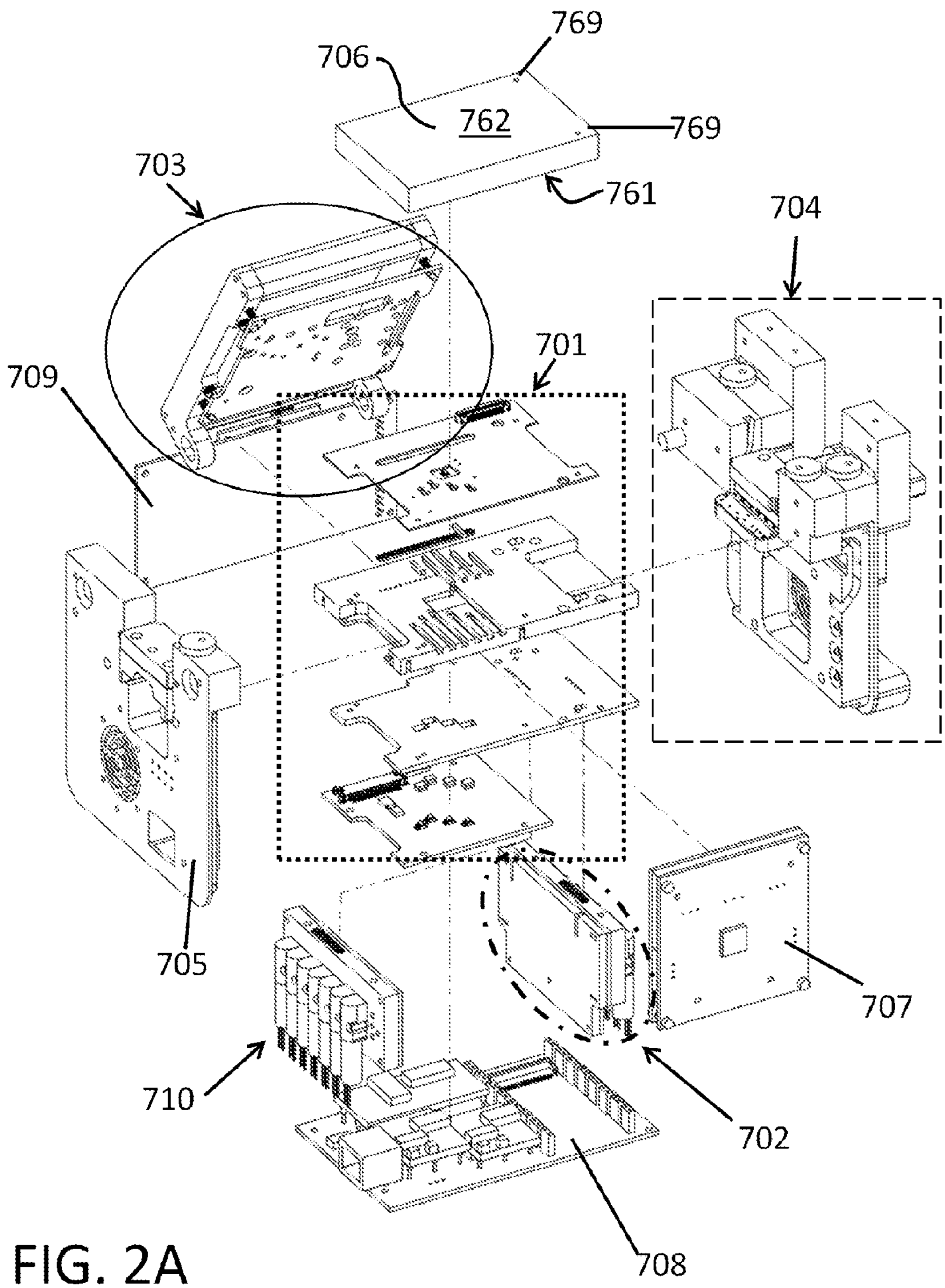


FIG. 2A

FIG. 2B

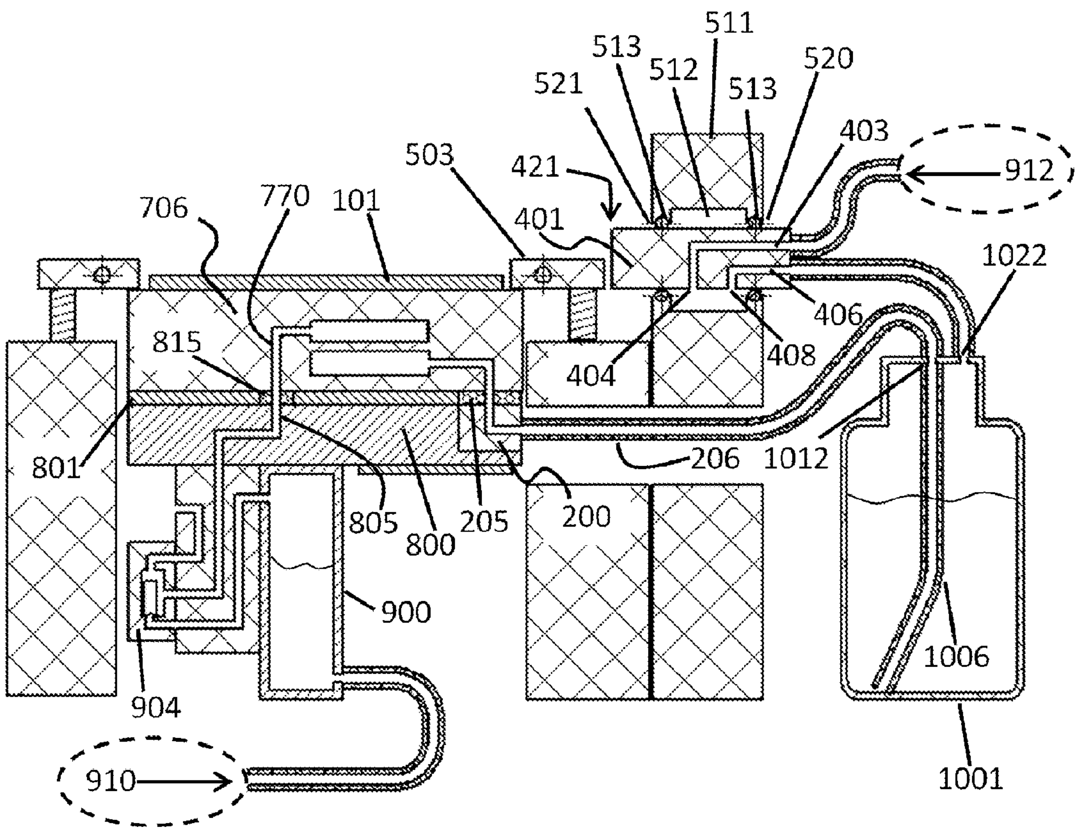


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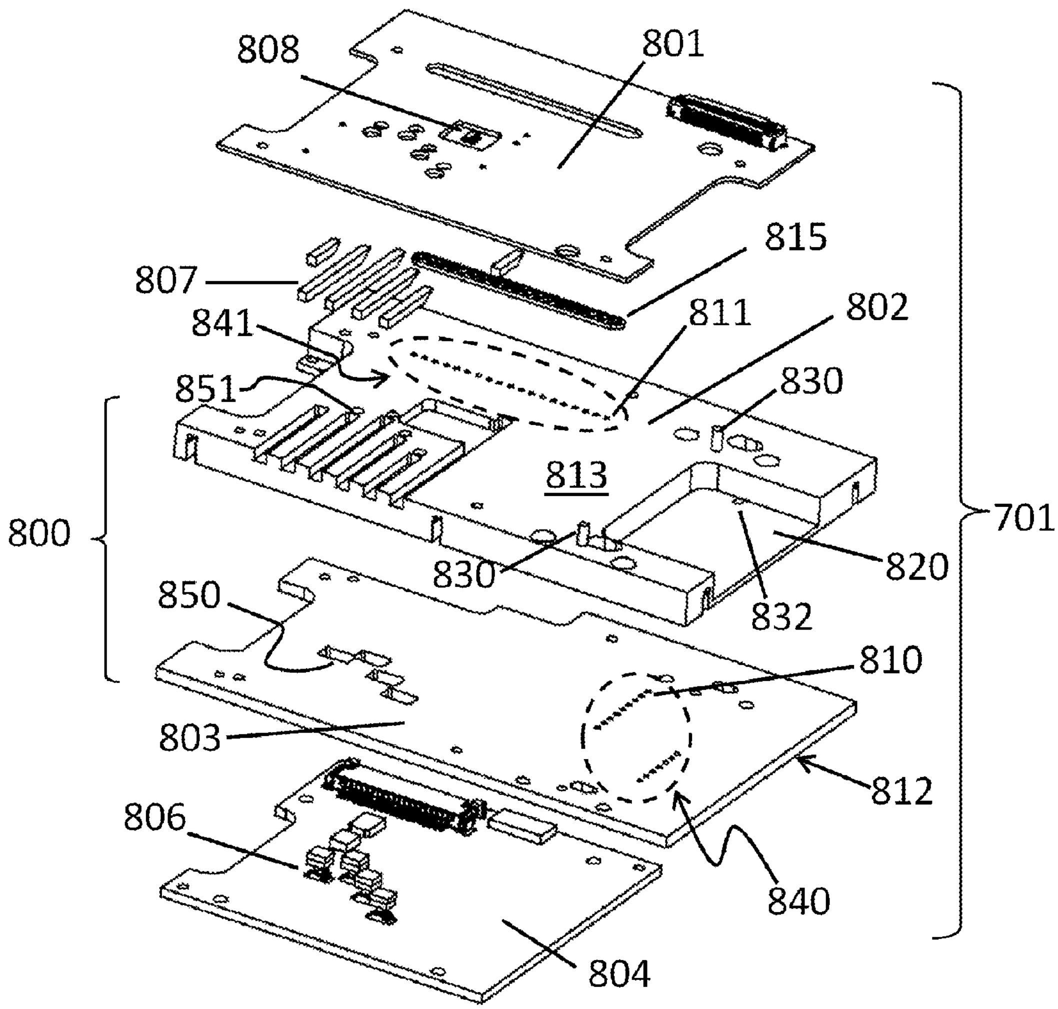
FIG. 3A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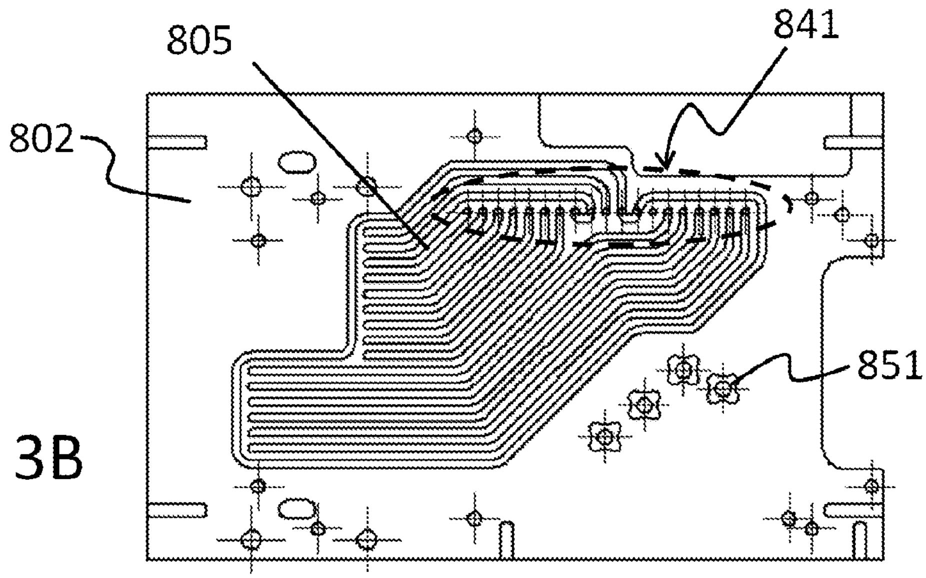

FIG. 3B

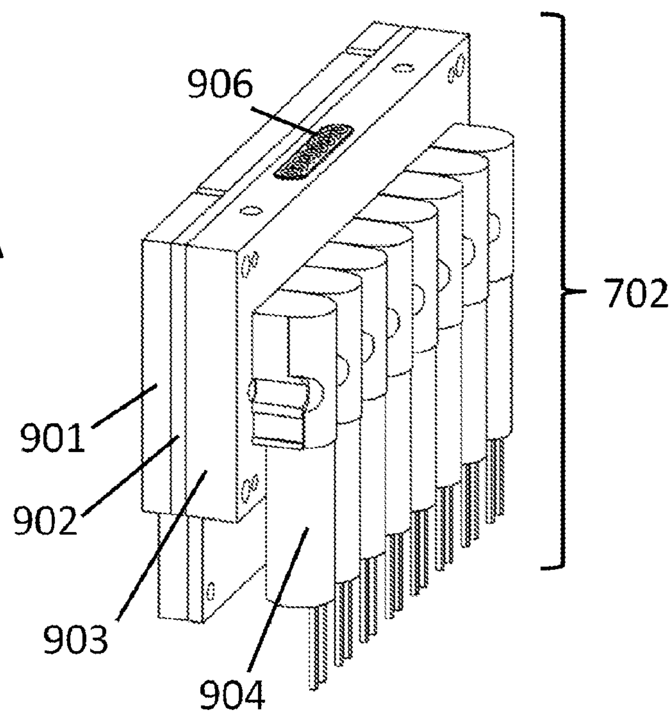

FIG. 4A

FIG. 4B

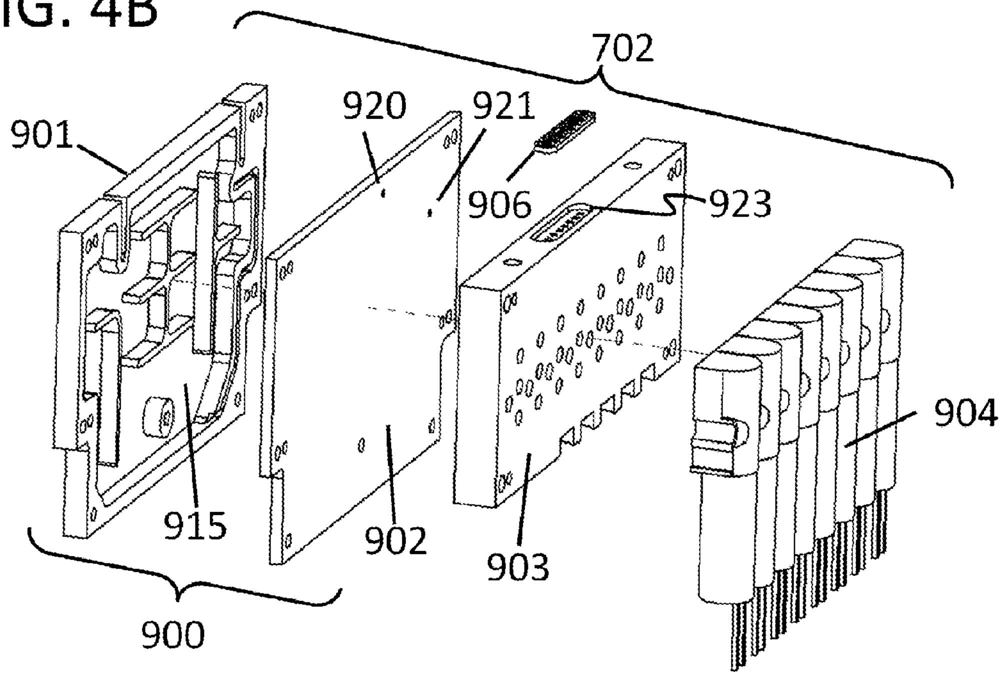
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FIG. 4C

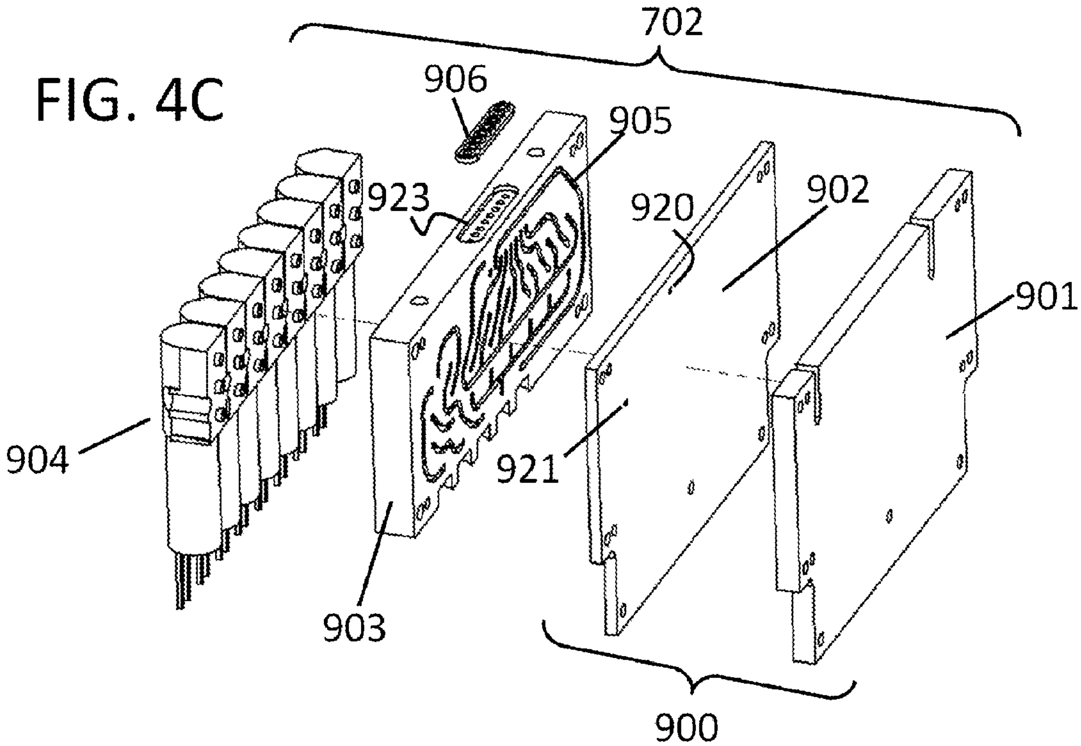
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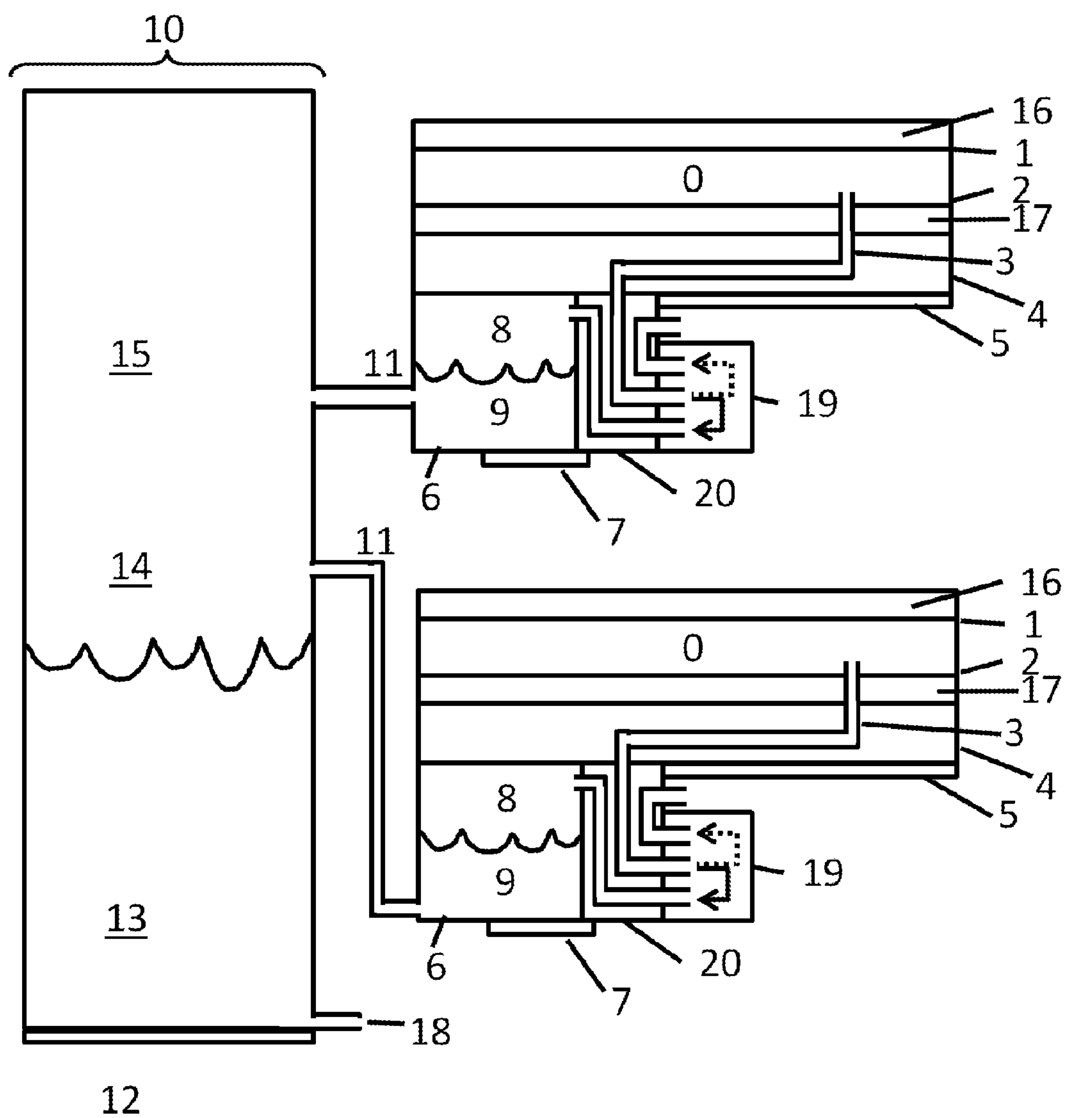
FIG. 5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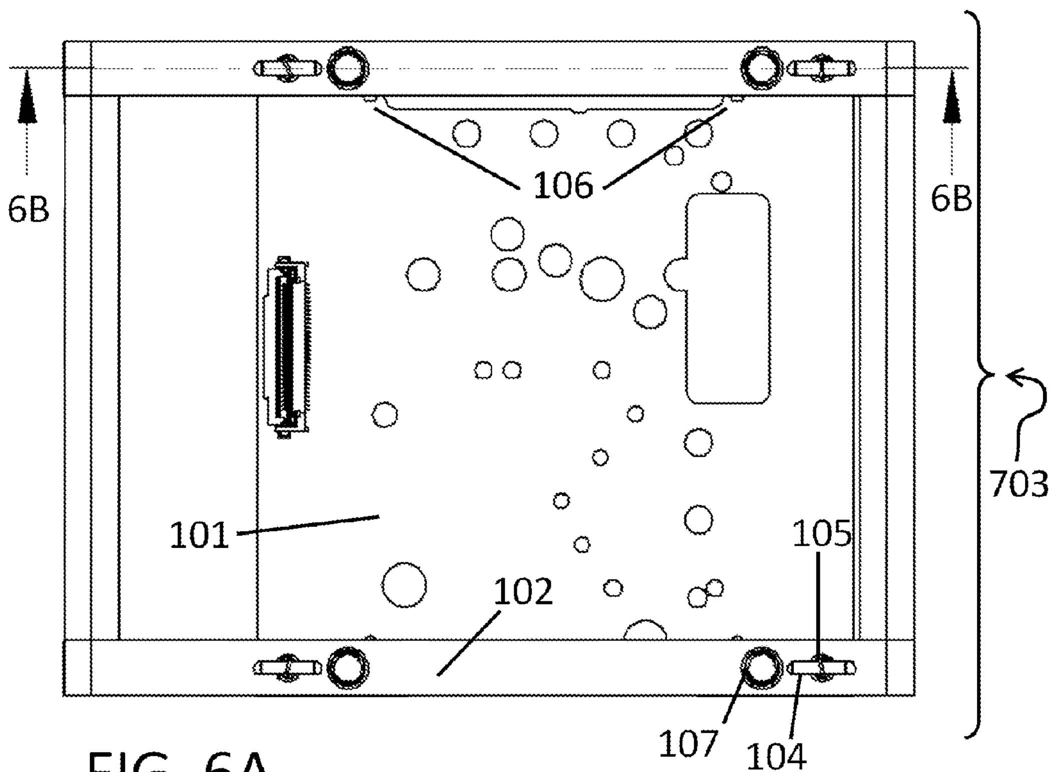

FIG. 6A

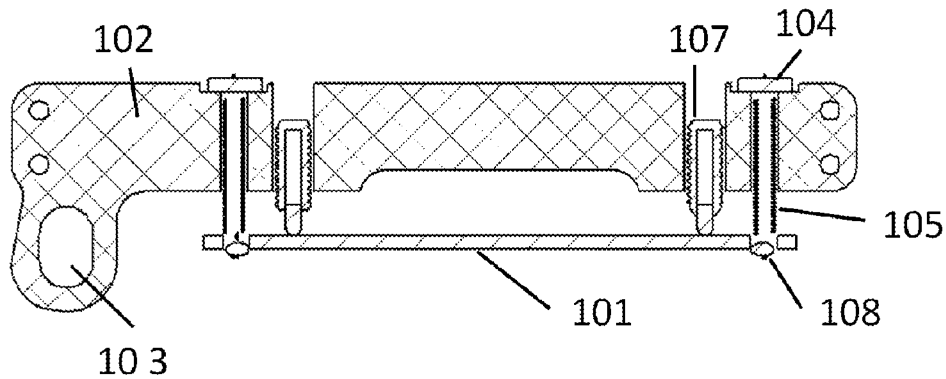

FIG. 6B

FIG. 7A

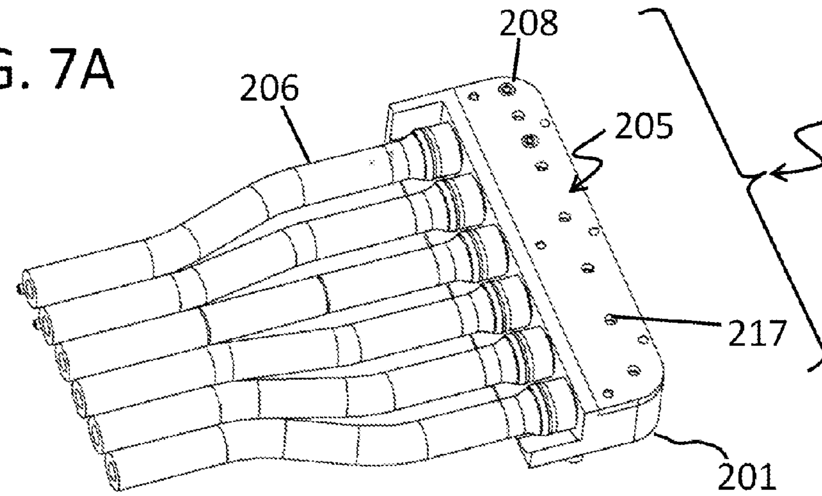
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FIG. 7B

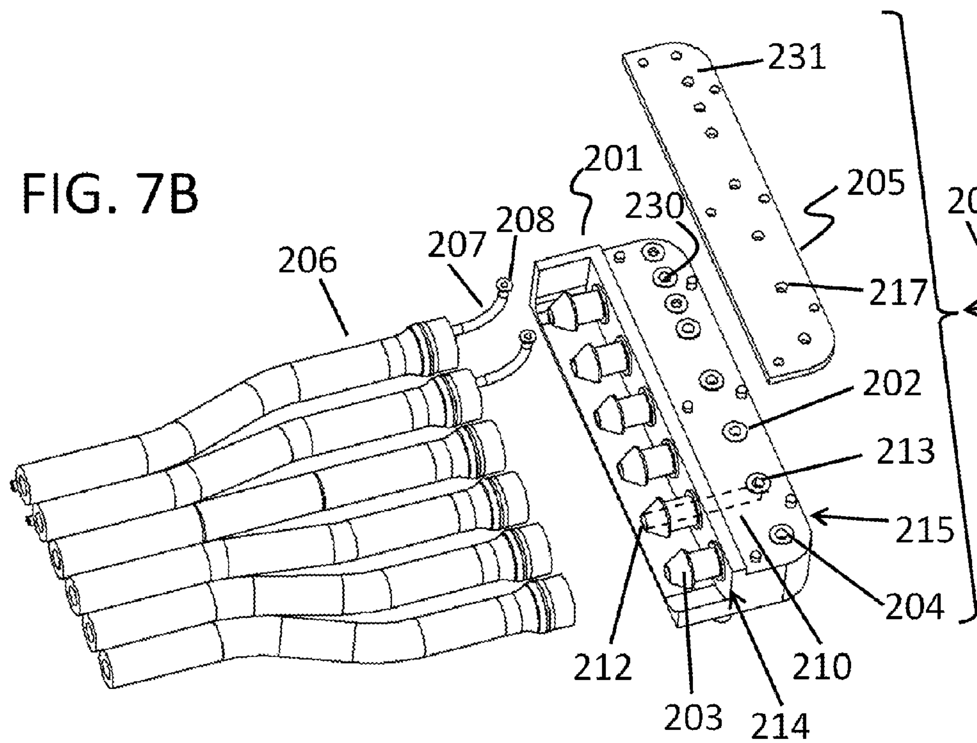
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FIG. 8A

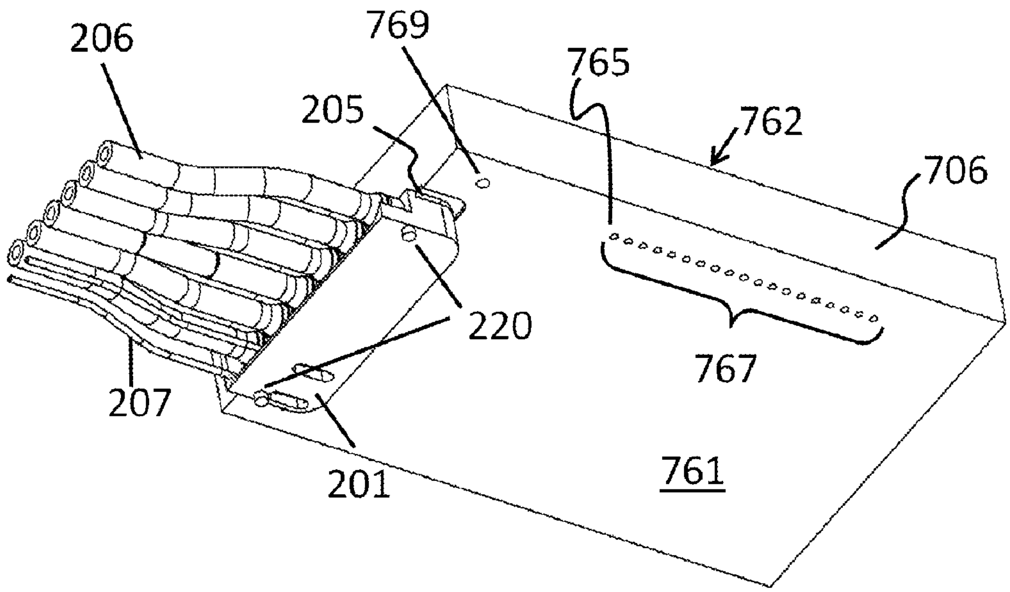
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FIG. 8B

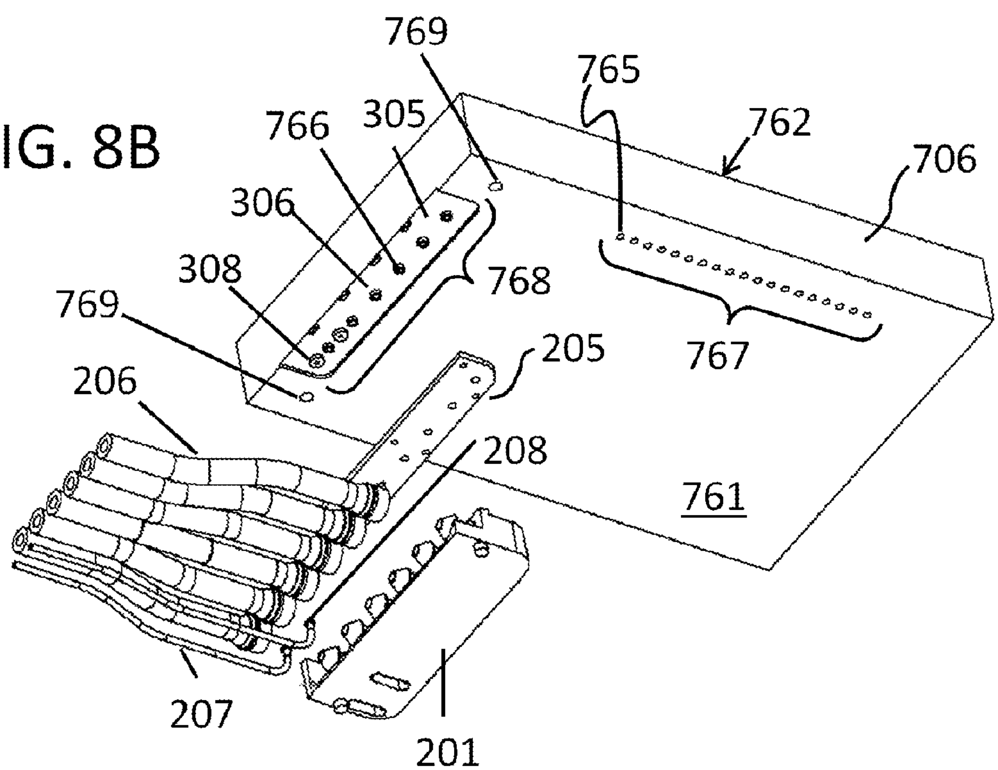
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FIG. 9A

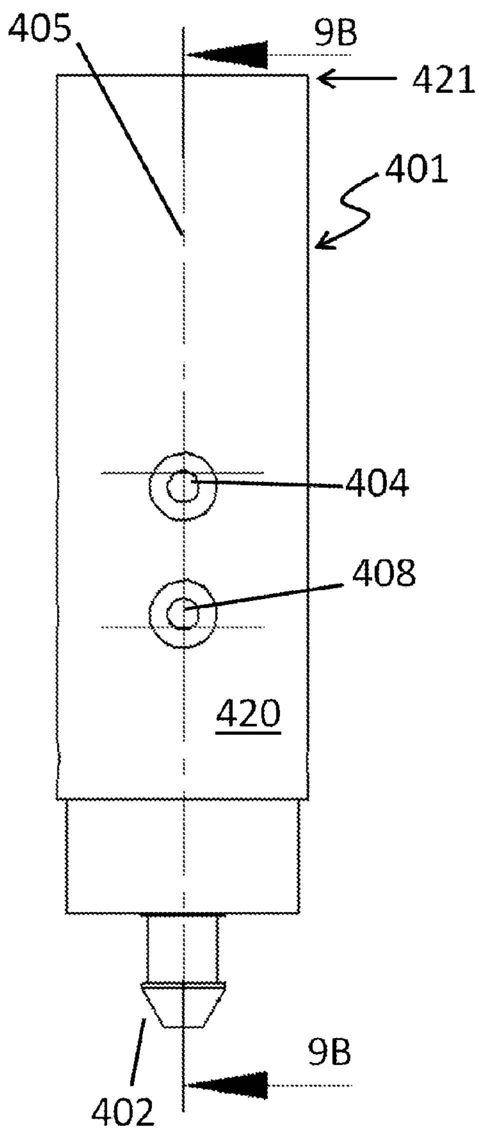
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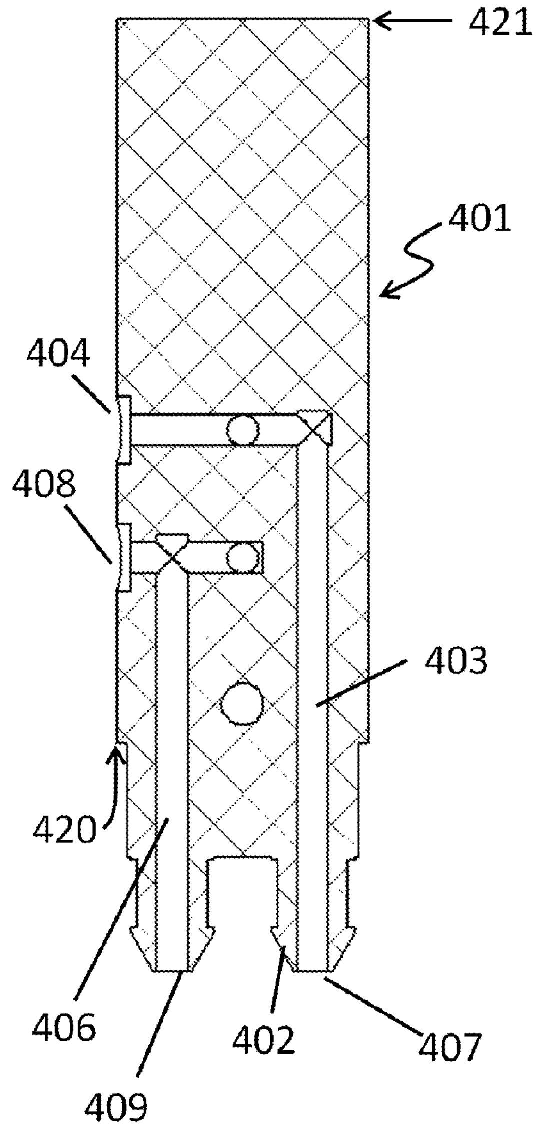
FIG. 9B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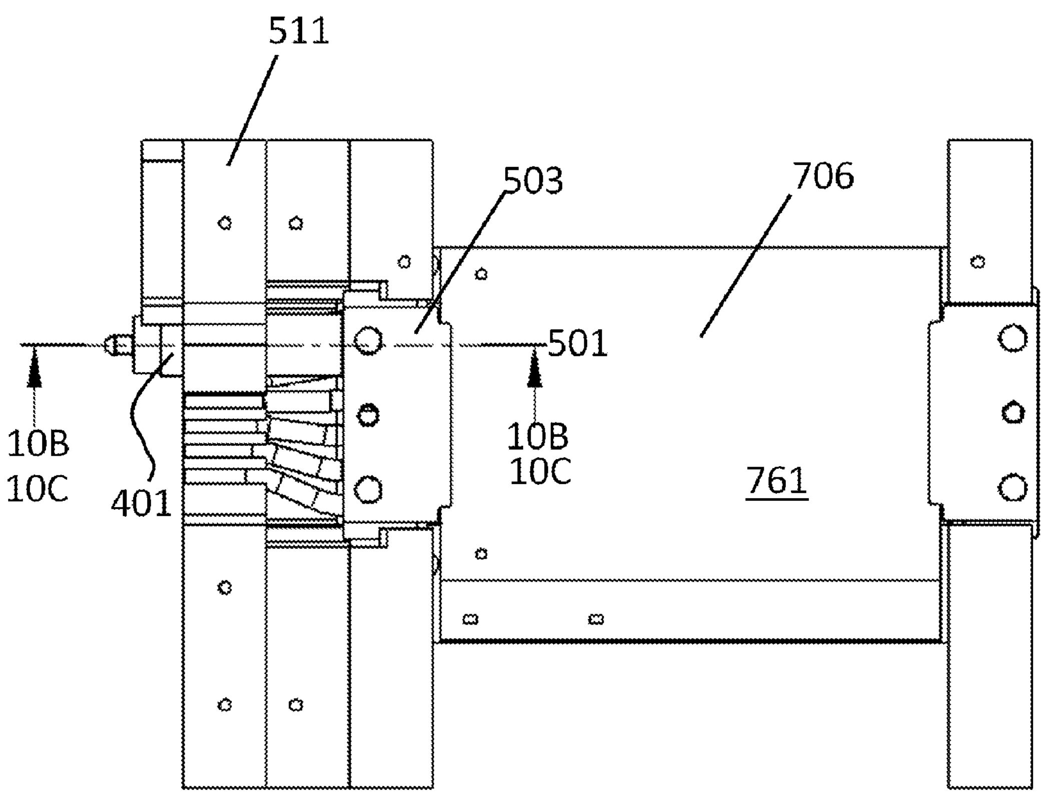

FIG. 10A

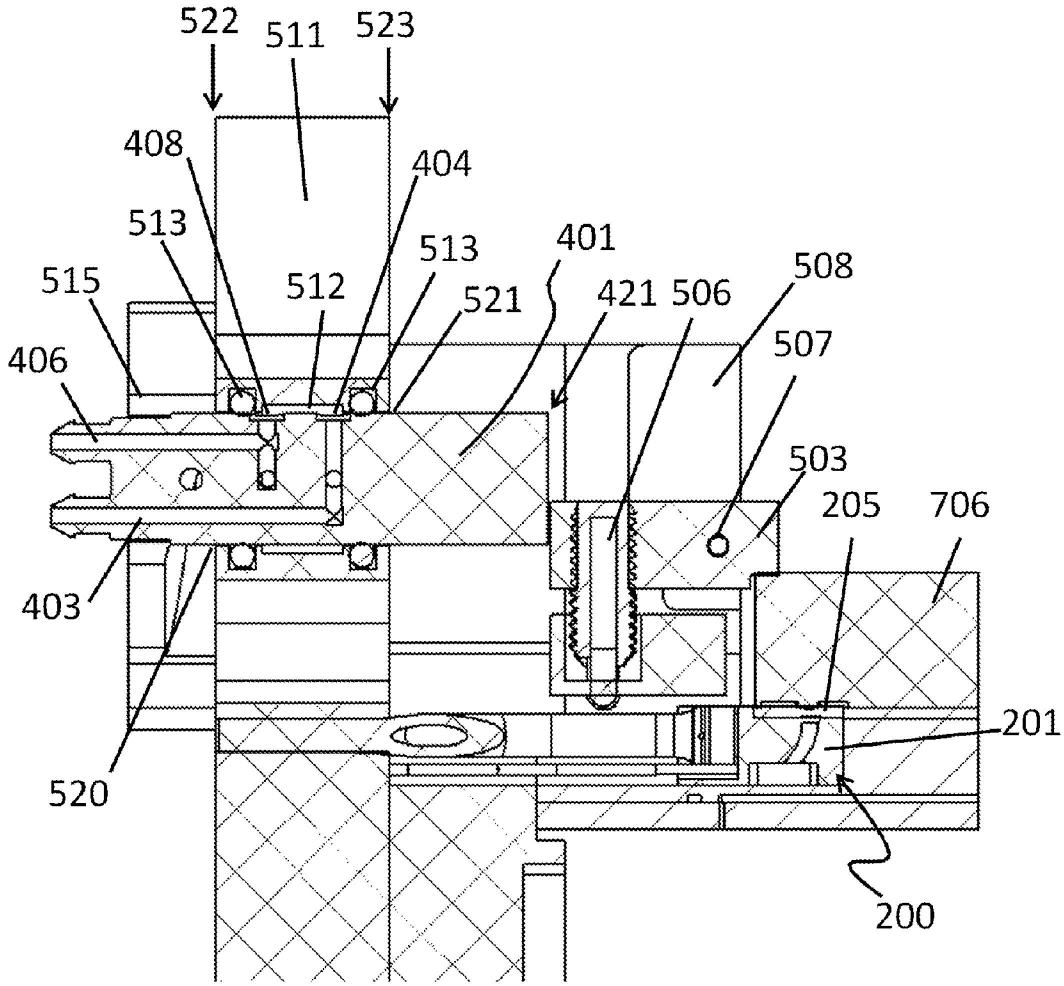
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FIG. 10B

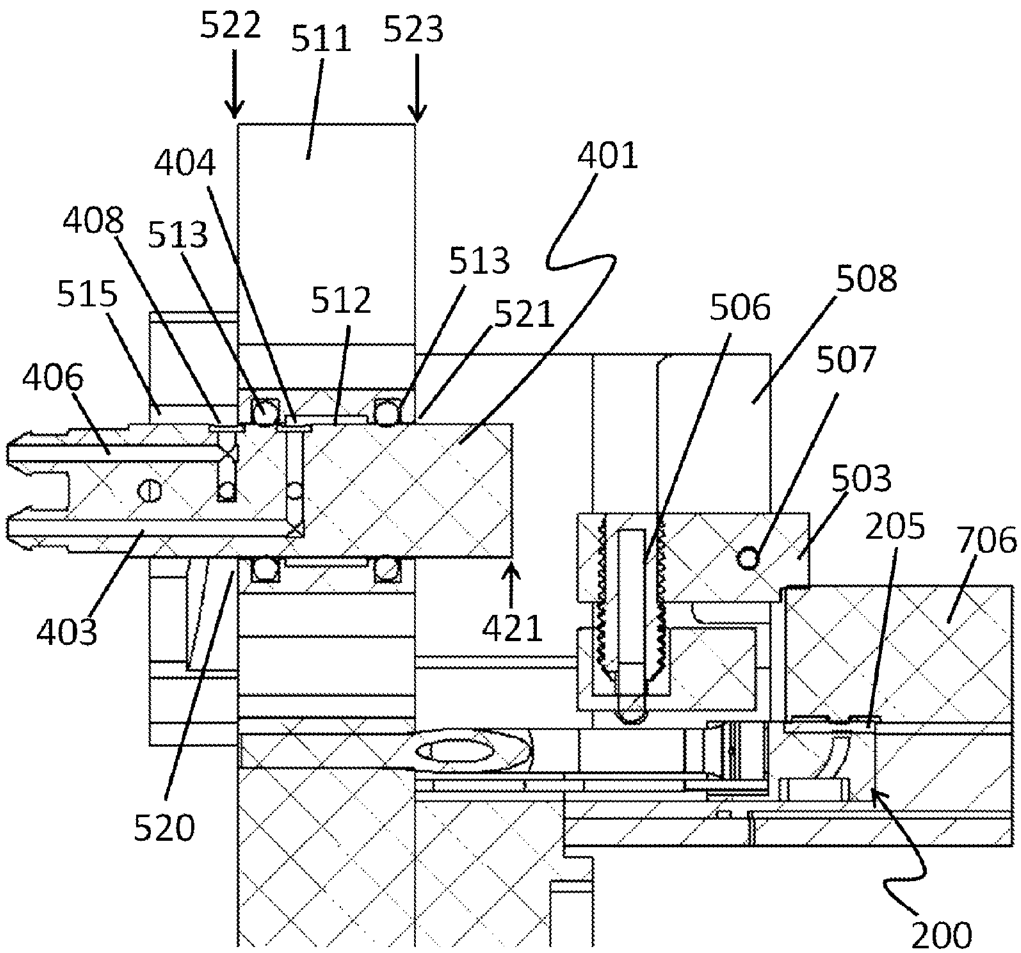

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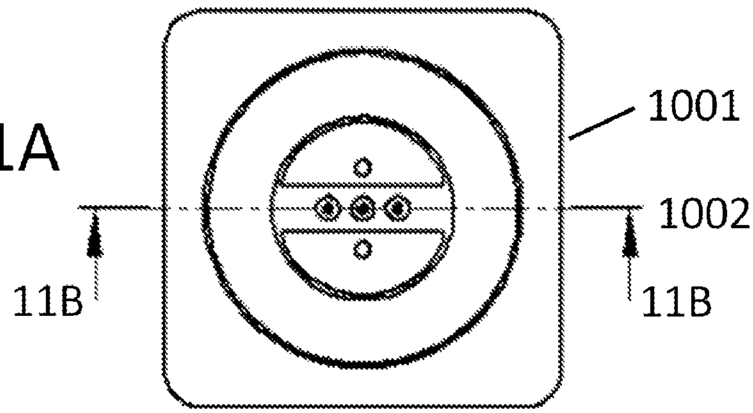
FIG. 10C

FIG. 11A



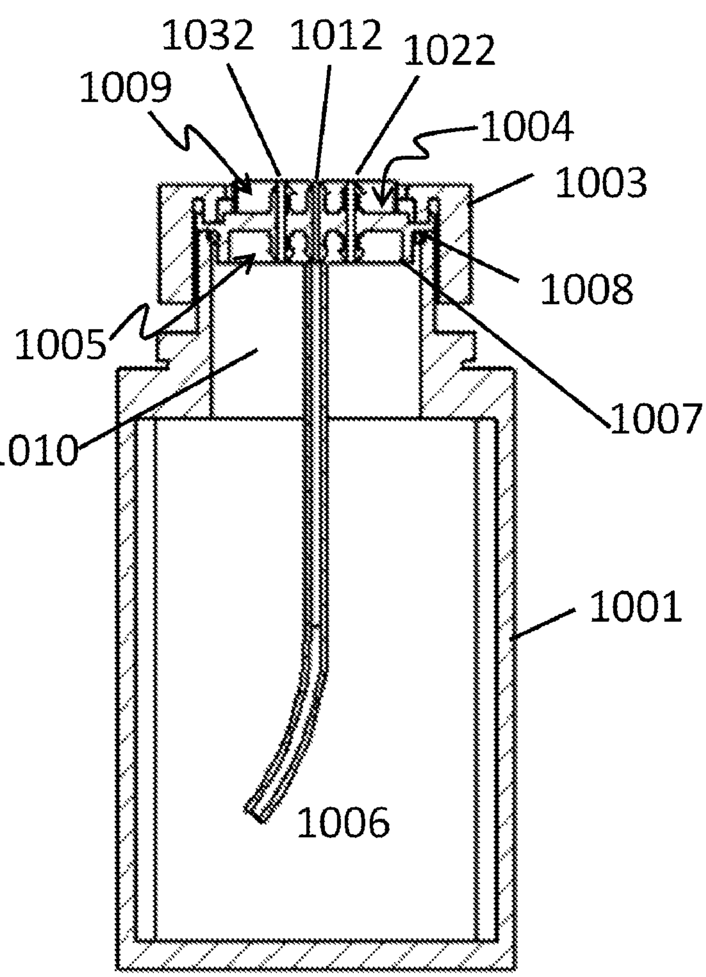


FIG. 11B

APPARATUS AND METHODS TO OPERATE A MICROREACTOR

RELATED APPLICATIONS

This application claims priority from U.S. Provisional Application No. 61/590,861, entitled "Systems, apparatus, and methods to operate small bioreactors" filed Jan. 26, 2012, the content of which is hereby incorporated by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This work was funded under federal grant number DE-FG02-08ER85207.

TECHNICAL FIELD

The field of the invention relates to apparatus and methods to interface and operate small scale microreactor devices.

BACKGROUND OF THE INVENTION

All referenced patents and applications are incorporated herein by reference in their entirety. Furthermore, where a definition or use of a term in a reference, which is incorporated by reference herein is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply.

Small scale bioreactors are intended to reduce the effort required to perform complicated fermentation and cell culture experiments, such as continuous cultures, and to provide the possibility of conducting these experiments in parallel. Continuous culture experiments, described for example in US2011/0053806A1, require the aseptic introduction of large volumes of fluid to the microfluidic device, typically many times the internal device volume. This requires an aseptic interconnection between at least one large volume aseptic reservoir and the aseptic microfluidic device. For parallel experiments, performing many of these aseptic connections efficiently is important. Conventional means to perform aseptic connections include the use of septa that block openings to channels in the microfluidic device, for example as in US2008/0241909A1 and puncturing the septa with a sterile needle connected to a source of sterile fluid, or making manual tubing connections between the fluid sources and the microfluidic device in a sterile environment. These methods require manual dexterity and are inconvenient when setting up many experiments.

There is also the requirement to supply a driving force to introduce the fluid into the device. This is typically done by supplying the fluid at a higher pressure than the fluid pressure in the device to generate a pressure driven flow. Under these conditions, with the fluid source at a pressure higher than the device, there is a risk of unintentional introduction of fluid to the area around the device should it be disconnected before equalizing the fluid pressure to atmospheric pressure. The unintentionally released fluid could damage sensitive equipment or contaminate clean surfaces.

An additional consideration for small scale bioreactors is loss of fluid due to evaporation. This is due to the large surface area to volume ratio of typical microfluidic devices. Minimizing fluid loss due to evaporation is important in order to minimize changes in the concentration of nutrients. Minimization of evaporation is particularly challenging because of the relatively high rate of gas exchange required to provide mixing and oxygenation to growing organisms. One approach to minimizing evaporation is to ensure the relative humidity of the gas that is exchanged with the bioreactor is near 100%. However, maintaining a high relative humidity of the gas increases the risk of condensation. Condensation of water has the negative effects of clogging channels designed for gas flow with liquid, and also interfering with optical or electrical measurements. To reduce or prevent condensation, any surfaces in contact with the humidified gas are set to temperatures higher than the condensation temperature of the humidified gas or the gas is dehumidified before reaching the surfaces of interest as in US5458008. However, since it is necessary to provide humidified gas to the devices performing liquid and gas reactions, dehumidifying the gas to prevent condensation before reaching the device is detrimental to system operation since it will not prevent fluid loss. Yet another method employed by US 2011/0076759 A1 is to implement a condenser at the output of the device to prevent evaporated liquid from leaving the device. While this method works in larger systems, smaller systems typically cannot afford to have cold regions close to temperature controlled or heated regions and systems relying on membranes for gas transfer have no method of returning condensed liquid to the device for reuse.

Thus, there is a need for an apparatus and methods to operate microfluidic bioreactors that provides convenient aseptic connections between microfluidic devices and large volume fluid reservoirs; mechanisms to reduce the chance of unintentional introduction of fluid around the device; and minimization of evaporation while at the same time avoiding condensation. In addition, such apparatus and methods should be efficient enough to use for many microfluidic bioreactors operated in parallel.

REFERENCED DOCUMENTS

All referenced documents are hereby incorporated in their entirety.

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2011/0076759 A1
U.S. Pat. No. 3,865,411

SUMMARY OF INVENTION

The present invention provides, apparatus and methods to interface to and operate a microreactor device through the controlled exchange of pressurized fluids with sources external to the microreactor device.

In preferred embodiments, a gas from a pressure source is delivered to a reservoir that is heated by thermal contact with a temperature controlled base plate. It is contemplated that water may be introduced to the reservoir to humidify the gas. The temperature controlled base plate comprises conduits with an openings on either side of the base plate to allow gas to remain heated and to pass from the reservoir to the microreactor device through solenoid switches which control the gas flow through each conduit. The temperature of the microreactor device is controlled through heating by thermal contact with the base plate on the bottom and thermal contact with a top heater. It is contemplated that maintaining the top heater temperature above the base plate temperature will prevent condensation. While in a preferred embodiment, conduits in the base plate have an opening on either side of the base plate, it is also contemplated that both openings are on the same side.

Another aspect of preferred embodiments is the mechanical mounting of the top heater by a hinged lid with protruding spring pins. The top heater is pulled against the spring pins by extension springs, allowing the heater to move laterally for alignment with the microreactor device. When the top lid is closed the spring pins push the heater against the microreactor device. Yet another aspect of preferred embodiments is a gasket and clamp to form a seal between the microreactor device and conduit in the base plate.

Another aspect of preferred embodiments is the interrogation of optical sensors in the microreactor device using a light emitting diode to excite the sensor, a waveguide to collect sensor emission and a photodiode to convert the optical signal to an electrical signal for processing.

It is further contemplated that in addition to delivering a gas to the microreactor, liquids from external sources may be delivered as well, including the delivery of liquids aseptically, preferably from sterilizable containers. Preferred embodiments include a fluid interface to translate fluid paths arriving from conduits of arbitrary size and form factor to the fluid paths of the microreactor device. It is contemplated that the fluid interface has conduits with openings on a substantially planar surface that correspond to openings on the microreactor device. A cavity in the base plate allows mounting of the fluid interface such that a gasket with corresponding openings can form a seal between the fluid interface and the microreactor device when the microreactor device is clamped onto the base plate.

In yet another aspect of preferred embodiments, a pressure interlock combines the mechanical action of preventing the clamp that seals the microreactor device to the fluid interface gasket from being removed with the act of pressurizing the fluid to be delivered through the fluid interface to the microreactor device. In a preferred embodiment, the pressure interlock comprises a prism having two conduits within, each conduit having an opening on the radial surface of the prism, and another opening on an axial surface of the prism. A preferred embodiment further comprises a cavity in a structural panel with openings having similar cross sectional area as the prism on each opposing side of the panel. A seal at each opening enables the formation of an enclosed volume when the prism is inserted through both openings. The axial position of the radial conduit openings is chosen such that when the structure panel is in a fixed position with respect to the clamped position of the clamp, and the prism, when inserted through the openings of the structure panel prevent the removal of the clamp, the two openings are in fluid communication within the cavity, and when the prism is moved so as not to block to removal of the clamp, one of the openings is outside of the cavity.

Another aspect of preferred embodiments provides methods to operate a microreactor device comprising the steps of controlling the temperature of the base plate to a first temperature range, controlling the temperature of the top heater to a second temperature range, and opening and closing a solenoid switch. Additional steps are contemplated including controlling the temperature of the reservoir to a third temperature range, introducing a fluid into the reservoir, constraining the first temperature range to be less than or equal to the second temperature range, and constraining the third temperature range to be less than the first temperature range.

Yet another aspect of preferred embodiments of the invention provides methods to exchange fluid with the microreactor device comprising the steps of inserting the fluid interface into the cavity of the base plate, aligning openings of the microreactor device to openings in gaskets, clamping the microreactor to the gaskets. Additional steps are contemplated including applying sterilizable tape to the fluid interface and microreactor device, sterilizing fluid containers, the fluid interface, and fluid conduits, introducing sterilized fluids to the containers, aligning the openings of the microreactor to openings in the gaskets, simultaneously removing the sterilizable tapes covering the fluid interface and microreactor, clamping the microreactor to the gaskets, and configuring a prism in a position to pressurize the fluid and prevent the clamp from being removed.

Embodiments of these and other aspects of the invention are described in more detail in the description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments of the present invention will now be described by reference to the following figures, in which identical reference numerals in different figures indicate identical elements and in which:

FIG. **1** shows a microreactor controller.

FIG. **2**A shows an exploded view of the microreactor controller.

FIG. **2**B shows a schematic side view of a microreactor controller.

FIG. **3**A shows an exploded view of a heated base plate manifold assembly.

FIG. **3**B shows a bottom view of the top layer of the heated base plate manifold.

FIG. **4**A shows a humidifier manifold and solenoid assembly.

FIG. **4**B shows an exploded view of the humidifier manifold and solenoid assembly from one angle.

FIG. **4**C shows and exploded view of the humidifier manifold and solenoid assembly from a second angle.

FIG. **5** shows a schematic side view of a humidification system for a plurality of microreactor controllers.

FIG. **6**A shows a top view of a heater and a hinged lid.

FIG. **6**B shows a side view cross-section of a heater and a hinged lid.

FIG. **7**A shows a fluid interface, gasket, and tubing.

FIG. **7**B shows an exploded view of a fluid interface, gasket, and tubing.

FIG. **8**A shows a view of a fluid interface, connected to a microreactor device.

FIG. **8**B shows an exploded view of a fluid interface connected to a microreactor device.

FIG. **9**A shows a top view of a pressure connector.

FIG. **9**B shows a cross-section view of a pressure connector.

FIG. **10**A shows a partial top view of the microreactor controller including a pressure interlock and fluid interface assembly.

FIG. **10**B shows a cross section view of the pressure interlock and fluid interface assembly in a pressurized configuration.

FIG. **10**C shows a cross section view of the pressure interlock and fluid interface assembly in a vented configuration.

FIG. **11**A shows a top view of a fluid bottle with hose barb cap insert.

FIG. **11**B shows a cross section side view of a fluid bottle with hose barb cap insert.

LEGEND FOR DRAWING REFERENCE LABELS

101 top heater
102 hinged lid frame

103 hinge pin hole
104 mechanical support (dowel pin)
105 Extension spring
106 alignment holes
107 spring pin
108 mechanical support for heater (dowel pin)
200 fluid interface
201 fluid interface body
202 protruding rings
203 hose barbs
204 openings inside a protruding ring
205 fluid interface gasket
206 conduit in fluid communication with the fluid interface body
207 direct tube through fluid interface
208 flare
210 internal conduit in fluid interface
212 first opening of fluid interface conduit
213 second opening of fluid interface conduit
214 first side of the body
215 second side of the body
217 opening in gasket
220 alignment posts
230 opening for direct tube in fluid interface body
231 opening in gasket for direct tube
305 surface of device that contacts fluid gasket
306 protruding rings of microreactor (smaller)
308 protruding rings on the microreactor
401 pressure connector
402 barb
403 first conduit within pressure connector
404 first opening of first conduit
405 section line
406 second conduit within pressure connector
407 second opening of first conduit
408 first opening of second conduit
409 second opening of second conduit
420 radial face of pressure connector
421 axial face of pressure connector
501 section line
503 clamp
504 clamp base
506 springs
507 pivot point
508 housing
511 structural panel
512 cavity
513 seals
515 locking mechanism
601 microreactor controller
701 heated base plate manifold assembly
702 humidifier manifold and solenoid assembly
703 lid assembly
704 pressure interlock and fluid interface assembly
705 connector panel group
706 microreactor device
707 photodiode board assembly
708 power and solenoid driver board
709 digital control module
710 valve-side solenoid manifold assembly
761 microreactor first side
762 microreactor second side
765 first opening
766 second opening
767 first group of openings
768 second group of openings
769 alignment holes
770 conduit within microreactor for air
800 heated base plate manifold
801 middle heater
802 base plate top
803 base plate bottom
804 bottom heater
805 manifold channels
806 LED
807 waveguide
808 temperature sensors
810 first opening
811 second opening
812 first surface
813 second surface
815 first gasket
820 cavity in base plate
830 cylindrical posts part of aligner for microreactor device
840 base plate first group of openings
841 base plate second group of openings
850 openings in base plate bottom
851 openings in base plate top
900 humidifier reservoir
901 reservoir layer
902 reservoir capping layer
903 solenoid manifold
904 solenoids
905 solenoid manifold channels
906 solenoid manifold gasket
910 first pressure source
912 second pressure source
915 cavity of humidifier reservoir
920 first opening in reservoir capping layer
921 second opening in reservoir capping layer
923 openings at top edge of solenoid manifold
1001 fluid bottle
1002 section line
1003 bottle cap
1004 insert for tubing connections
1005 inside barbs
1006 tubing
1007 ring
1008 o-ring
1009 outside barbs
1012 outlet of bottle
1022 inlet to bottle

DETAILED DESCRIPTION OF THE INVENTION

Detailed Description of the Drawing

The drawing refers to preferred embodiments of the invention and the particular components, materials, and dimensions, as well as other details are to be interpreted to apply broadly in the art and should not be construed to unduly restrict or limit the invention in any way.

Referring now to a preferred embodiment in more detail, FIG. **1** shows an isometric view of a microreactor controller **601** used to operate a microreactor device **706**. The microreactor controller comprises: a lid assembly **703** comprising a top heater **101**, a hinged lid **102**, a photodiode board assembly **707**, a humidifier reservoir and solenoid assembly **702**, a clamp **503**, a power and solenoid driver board **708**, and a structure panel **511**. Also shown are two alignment holes **769** of the microreactor device **706**. The photodiode board assembly **707** comprises photodiodes and amplifier electronics coupled to an analog to digital conversion board. The power and solenoid driver board **708** comprises DC-DC converters and solenoid driver amplifiers.

FIG. **2**A shows an exploded view of the microreactor controller **601**. For the purposes of a more detailed description, the microreactor controller comprises four main groups, a heated base plate manifold assembly **701**, a humidifier manifold and solenoid assembly **702**, a lid assembly **703**, and a pressure interlock and fluid interface assembly **704**, as well as the additional components of a photodiode board assembly **707**, a power and solenoid driver board **708**, a connector panel **705**, a digital control module **709** comprising a field programmable gate array, and a valve-side solenoid manifold assembly **710**. Also shown is an outline of a microreactor device **706**, having a first side **761**, a second side **762**, and two alignment holes **769**.

FIG. **2**B shows a schematic view of a microreactor controller, highlighting the aspects related to delivery of fluids to a microreactor device **706**. To deliver humidified gas to the microreactor device **706** to minimize evaporation, while at the same time minimizing condensation, the temperature of the humidified gas must not decrease below the dew point. It is therefore preferred to heat all of the surfaces between the generation of humid gas through the delivery of the humid gas to the microreactor device. This can be accomplished by coupling a humidifier reservoir **900** comprising a thermally conductive material to a heated base plate manifold **800**. Pressurized humid gas is generated by coupling a first pressure source **910** to the humidifier reservoir **900**, which comprises a volume of water. The pressurized humidified gas can then be selectively introduced to a conduit **805** within the heated base plate manifold that is in fluid communication with a conduit **770** within the microreactor device **706** by actuating a solenoid switch **904**. To minimize condensation it is preferred to heat the microreactor device **706** uniformly from both the top and bottom. Heat from the bottom comes from a middle heater **801** and thermal contact with the heated base plate manifold **800**. Heat from the top comes from a top heater **101**. To interface a microreactor **706** with a liquid, preferably aseptic liquids, it is preferred to use a removable fluid container **1001** and fluid interface **200** so that they may be separately sterilized from the rest of the microreactor controller. The fluid interface **200** translates the form factor of the fluid conduits **206**, into a format that is compatible with the microreactor device. An example is the translation between ⅛ inch diameter tubing to an array of 0.036 inch openings. By utilizing aligners, where mating geometrical features constrain the position of the microreactor or other components with a reference component, such as the heated base plate manifold **800**, microreactor devices requiring many pneumatic signals and many fluid feeds can be conveniently interfaced where a seal between the openings in the heated base plate manifold **800** and fluid interface **200** are accomplished with gaskets **815** and **205** and a clamp **503** or multiple clamps to press the microreactor device **706** onto the gaskets **815** and **205**, forming a seal.

Because fluid delivery to the microreactor device depends on pressure driven flow, liquids must be supplied under pressure. This introduces a risk that if the user accidentally removes the clamp **503**, liquid will flow out of the fluid interface and flow to undesirable locations. To prevent this problem, it is preferred to use a pressure interlock that prevents removal of the clamp when the fluid is pressurized. This can be accomplished with a structural panel **511** comprising a cavity **512** with openings **520** and **521** on either side of the structural panel **511**. Seals at each opening **520** and **521** allow a sealed enclosed volume to be formed when a pressure connector **401** in the shape of a prism is inserted into the openings **520** and **521**. The pressure connector has two conduits **403** and **406** with corresponding openings **404** and **408** on the radial surface of the pressure connector **401**. When the pressure connector **401** is inserted into the cavity **512** such that the two openings **404** and **408** are between the seals **513**, conduits **403** and **406** are in fluid communication within the cavity and pressure from a second pressure source **912** is transmitted from conduit **403** to conduit **406** and subsequently the bottle **1001**. In this configuration the pressure connector **401** blocks the clamp **503** from being removed. When the pressure connector is moved so that the opening **404** is between the seals and opening **406** is outside of the seals, the bottle **1001** is vented, the pressure source **912** is blocked, and the clamp **503** can be removed.

In more detail FIG. **3**A, shows the heated base plate manifold assembly **701** comprising: a middle heater **801**; a two layer heated base plate manifold **800** comprising a base plate top **802**, and a base plate bottom **803**; and a bottom heater **804**. A first group of holes **840** in the base plate bottom **803** has a position that corresponds to a first set of endpoints of channels **805** on the bottom of base plate top **802** as shown in FIG. **3**B. The second set of endpoints of channels **805** coincide with a second group of holes **841**, shown in both FIG. **3**A and FIG. **3**B. When the base plate top **802** and base plate bottom **803** are bonded together to form a heated base plate manifold **800** using means known in the art, such as using an adhesive film, such as a pressure sensitive silicone adhesive, or other adhesive, the channels **805** and first hole group **840** and second hole group **841** form conduits inside the heated base plate manifold. Middle heater **801** and bottom heater **804** located mounted in thermal communication with, respectively, the base plate top **802** and base plate bottom **803** provide the capability to raise the temperature of the heated base plate manifold **800**. It should be clear to one of ordinary skill in the art that temperature control is enabled by measuring the temperature of the heated base plate manifold **800** and adjusting the heating power delivered by the heaters. Cooling the heated base plate manifold **800** can be accomplished using a fan to increase convective heat transfer from the heated base plate manifold **800**.

In even more detail in FIG. **3**A, middle heater **801** and bottom heater **804** can be made of materials used to make circuit boards such as but not limited to copper, aluminum, fiberglass, epoxy, or gold. Other types of heaters are also possible, such as water jacket heaters or chemical heaters. The heaters in a preferred embodiment can be between 6 square inches and 12 square inches in area, or between 1 and 50 square inches in area and between 0.01 and 0.0625 inches thick or between 0.01 and 0.2 inches thick. Other components for sensing or control, such as waveguides **807**, light emitting diodes **806**, or temperature sensors **808** may be incorporated as well. In particular it is preferred to mount light emitting diodes **806** on the bottom heater **804** so the light is projected upwards through openings **850** in the base plate bottom **803** and openings **851** in the base plate top **802** to excite optical sensors inside the microreactor devices. Optical emission from the optical sensors can then be collected by the waveguides and transmitted to the photodiodes on the photodiode board assembly **707**.

The base plate top **802** and base plate bottom **803** can be made of thermally conductive or thermally capacitive materials such as but not limited to aluminum, copper, iron, or steel to improve temperature uniformity. If temperature uniformity is not important or not an issue due to factors such as thickness or degree of insulation, less thermally conductive or thermally capacitive materials can also be used such as but not limited to polycarbonate, acrylic, polypropylene, peek, or nylon. The base plate top **802** and base plate bottom **803** can be between 6 square inches and 15 square inches in area, or between 1 square inch and 50 square inches in area and between 0.02 and 0.2 inches thick or between 0.01 and 1 inch thick. Channels **805** on the bottom side of the manifold layer **802**, can be 0.02 inches wide or between 0.001 and 0.2 inches wide and 0.01 inches deep or between 0.001 and 0.15 inches deep.

FIG. **4**A shows the humidifier manifold and solenoid assembly **702**. The exploded view in FIG. **4**B shows a humidifier reservoir **900** comprising a reservoir layer **901** and a reservoir capping layer **902**, a solenoid manifold **903**, and solenoids **904**. FIG. **4**C shows an exploded view of the humidifier manifold and solenoid assembly **702** from a reverse angle to show the locations of solenoid manifold channels **905** in the solenoid manifold **903**.

In more detail, bonding the reservoir layer **901** and reservoir capping layer **902** together using means known in the art such as adhesive bonding with an adhesive film, such as a pressure sensitive silicone adhesive film, or other adhesive forms a humidifier reservoir **900**, with a cavity **915** that can be accessed externally through two openings **920** and **921** in the reservoir capping layer **902**. Conduits are formed in the solenoid manifold **903** when it is bonded, using means known in the art, to the reservoir capping layer **902**. The conduits connect the openings in the reservoir capping layer, and therefore the cavity **915** in the humidifier reservoir **900**, with ports of a solenoid switch. In general, the solenoid manifold channels **905** are configured to deliver the appropriate pressure, switched by the solenoids **904** to the openings **923** at the top edge of the solenoid manifold **903**. Typically switching is between a supplied pressure and atmospheric pressure. The humidifier manifold and solenoid assembly **702** interfaces with the heated base plate manifold assembly **701** with a solenoid manifold gasket **906**. Preferably, the openings **923** at the top edge of the solenoid manifold are aligned with the openings **840** in the heated base plate manifold **800**. While a gasket is used in a preferred embodiment, other connection methods can be used such as but not limited to tubes, adhesives, or direct welding.

In more detail in FIG. **4**B and FIG. **4**C, the reservoir layer **901**, and reservoir capping layer **902**, and manifold layer **903** can be made of a thermally conductive or thermally capacitive material such as but not limited to aluminum, copper, iron, or steel to improve temperature uniformity. If temperature uniformity is not important or not an issue due to factors such as thickness or degree of insulation, less thermally conductive or thermally capacitive materials can also be used such as but not limited to polycarbonate, acrylic, polypropylene, peek, or nylon. Solenoids **904** can be purchased from a variety of vendors known to those of ordinary skill in the art. The reservoir layer **901**, reservoir capping layer **902**, and solenoid manifold **903** can be 5 inches square in area or between 0.5 and 20 inches square in area and between 0.02 and 1 inch thick. The gasket **906** can be made of a compressible material such as but not limited to silicone, butyl rubber, EPDM, or viton. The gasket **906** can be between 0.04 and 0.5 inch wide and between 0.1 and 3 inches long.

FIG. **5** shows a schematic of a preferred embodiment for implementing a system to reduce evaporation from and condensation in devices containing fluids and gases. While equivalent components and features in FIG. **5** also exist in FIG. **2**, FIG. **3**A, FIG. **3**B, FIG. **4**A, FIG. **4**B, and FIG. **4**C, numbering is changed to differentiate the schematic representations of the components from their model counterparts. The device **0** comprising a top surface **1** and bottom surface **2** is heated by heaters located at the top surface **16** and the bottom surface **17**. Humidified gas **8** is delivered to the device through a pressure manifold **4** located under the device through channels **3** in the pressure manifold. The pressure manifold is also heated with a heater **5**. Attached to the pressure manifold is a solenoid manifold **20** containing at least one solenoid switch **19** to provide control of gas flow. Attached to the solenoid manifold is the first humidifier **6** comprising humidified gas **8** and a heated first liquid **9**. The first humidifier is heated by a heater **7** and is also in contact with the pressure manifold resulting in heating from the pressure manifold heater as well. To replace lost fluid due to evaporation in the humidifier, a channel **11** is connected from the output of a second humidifier **10** to the first humidifier **6**. Since only humidified gas **14** is necessary for replacement, the connecting channel **11** is nominally placed in the headspace **15** of the second humidifier to prevent the second humidifier liquid **13** from directly flowing into the first humidifier. The second humidifier is also heated by a heater **12** and comprises a gas input **18** to maintain pressure.

In more detail, FIG. **5** shows a schematic of a humidification system. A first humidified gas **8** is delivered to the device **0** through a heated pressure manifold **4** from a heated first humidifier **6** containing fluid **9**. Supplying a first humidified gas to the device minimizes evaporation. Condensation is prevented by setting the temperature of the top surface **1**, bottom surface **2**, and pressure manifold **4** to values greater than or equal to the temperature required to condense the first humidified gas. Keeping the humidifier on the order of the device size and close to the device enables the introduction of high humidity gas into the device without condensation while relaxing heating requirements. The temperature of all surfaces in contact with the first humidified gas after the first humidifier are equal to or greater than the temperature required to condense the first humidified gas. In a preferred embodiment, the temperatures of the top surface of the device, bottom surface of the device, pressure manifold channel **3**, and first humidifier are set to 37 degrees centigrade or between 27 and 40 degrees centigrade, through the use of heaters **5**, **7**, **16**, **17** in direct contact with the objects listed above. In a preferred embodiment, the pressure manifold and first humidifier each contain at least one metal surface to improve temperature uniformity. While the drawing shows the locations of heaters for a preferred embodiment, one with ordinary skill in the art would know that heating can be accomplished with more or less heaters and in many different configurations of heaters. In a preferred embodiment, if switching capability is desired, solenoid switches **19** can be added to the pressure manifold, or an additional manifold **20** located after the first humidifier with added components heated either directly with an additional heater, through the switches themselves, or passively through contact with existing heaters. If the volume of the first humidifier is smaller than required to operate the device, a second humidifier **10** with associated heater **12** of larger volume containing a second humidified gas **14** and fluid **13** can be connected at the input to the first humidifier. In a preferred embodiment, the volume of the first humidifier is less than 10 milliliters or between 4 and 6 milliliters and the volume of the second humidifier is less than 5 liters or between 0.25 and 1 liter where volume refers to the combined fluid and gas volume. In a preferred embodiment, the temperature of the second humidifier is between 20 and 100 degrees centigrade or 37 degrees centigrade. The temperature of the channel **11** between the first and second humidifier need not be higher than the temperature required for the second humidified gas to condense but must be higher than the temperature required for the fluid in the second humidifier to freeze. Fluid condensed between the first and second humidifier will enter the first humidifier and supply fluid for the first humidified gas. In a preferred embodiment, the temperature of the connection is uncontrolled at a room temperature of 20 degrees centigrade or between 10 and 30 degrees centigrade and the connection is a 8 foot long tube or between 2 and 10 foot long tube. In a preferred embodiment, one or more channels are connected between the headspace **15** of the second humidifier and one or more first humidifiers. This connection strategy ensures that condensed fluid and humidified gas are delivered independently to each first humidifier.

Referring now to a preferred embodiment in more detail, FIG. **6**A shows the lid assembly **703** comprising a top heater **101** and a hinged lid frame **102**. The top heater **101** supported on to the hinged lid frame **102** using extension springs **105** fastened by mechanical supports **104** such as a dowel pin. Spring pins **107** push against the top heater **101** such that the extension springs **105** are extended beyond their relaxed length. The heater has alignment holes **106** as part of an aligner to align the top heater with a microreactor device **706**.

Referring now to a preferred embodiment in more detail, FIG. **6**B shows a section view of FIG. **6**A along the section line **6**B-**6**B. The hinged lid frame **102** comprises hinge pin holes **103** to attach the hinged lid frame **102** to a supporting structure. The heater **101** is attached to hinged lid **102** through extension springs **105**. The extension springs **105** are attached to mechanical support **104** on the hinged lid frame **102** and mechanical support **108** on the heater **101**. The heater **101** is also pushed away from the hinged lid **102** using spring pins **107** attached to the hinged lid **102**.

Now in more detail, FIG. **6**A and FIG. **6**B show a top heater **101** attached to a hinged lid frame **102** such that the top heater **101** can be moved laterally to be aligned to a supporting structure or microreactor device **706**. To ensure contact under pressure between the top heater **101** and the structure or microreactor device **706**, spring pins **107**, apply pressure when the top heater **101** is pushed against the structure or device, compressing the spring within the spring pin. To secure the top heater **101** to the hinged lid frame **102**, extension springs **105** are used and secured with mechanical supports **104**, **108**. By attaching the top heater **101** to the hinged lid frame **102** using extension springs **105** or any other deformable object, the top heater **101** is able to move with respect to the hinged lid frame **102** which is usually necessary if the top heater **101** is intended to align to a supporting structure, in this case by using alignment holes **106** or other mechanical alignment structure. The alignment holes are useful if the top heater **101** comprises other structures which should be aligned to the supporting structure or device, such as optical, fluid, or pneumatic components. The hinged lid frame **102** is attached to another supporting structure or hinge through holes **103** which allows the hinged lid frame **102** to rotate on the axis of the holes **103**. The holes **103** can be circular or oval shaped to accommodate supporting structures underneath the top heater **101** which are of varying sizes and thicknesses.

In further detail, in FIG. **6**A and FIG. **6**B, the top heater **101** can have a thickness of 0.03125 inch or between 0.02 and 0.125 inch, a length of 3 inch or between 1 inch and 10 inch, and a width of 2.5 inch or between 1 inch and 10 inch. The top heater **101** can be made of rigid materials such as but not limited to fiberglass, epoxy, acrylic, copper, aluminum, or steel. The hinged lid frame **102** can be of similar size to the heater, with a length of 4 inches or between 1 inch and 10 inches, a width of 3 inches or between 1 inch and 10 inches, and a thickness of 0.4 inches or between 0.1 inches and 10 inches. The hinged lid frame **102** can also be made of rigid materials such as but not limited to fiberglass, epoxy, acrylic, copper, aluminum, or steel. Holes **103** on the hinged lid frame **102** can be 0.25 inch diameter, or between 0.0625 and 2 inch diameter if circular. If non-circular, holes **103** can be 0.25 inch wide or between 0.0625 and 2 inch wide and 0.5 inch long or between 0.0625 and 2 inch long. Extension springs **105** can be 0.4 inch long or between 0.04 inch and 2 inch long when unextended and a diameter of 0.09 inch or between 0.04 inch and 0.5 inch and can be made of any spring material such as but not limited to steel, stainless steel, bronze, or brass. Mechanical supports **104**, **108** can physically be part of the top heater **101** and hinged lid **102** or be additional structures such as rods or bars made of materials such as but not limited to fiberglass, epoxy, acrylic, copper, aluminum, steel, nylon, teflon, or polycarbonate and can be 0.0625 inch wide or between 0.02 and 1 inch wide and 0.1 inch long or between 0.02 and 1 inch long. Spring pins **107** can be compression springs or spring pins and can be made of materials such as but not limited to steel, stainless steel, bronze, brass, acetal, or nylon, and can be 0.16 inch or between 0.03125 and 1 inch diameter. Alignment holes **106** can be round or polygonal with a, for example, maximum dimension of 0.0625 inches or between 0.02 and 2 inches.

Referring now to a preferred embodiment in more detail, FIG. **7**A shows an isometric view of an assembled fluid interface **200** comprising a fluid interface body **201**, a fluid interface gasket **205**, and a conduit **206** in fluid communication with the fluid interface body **201**. In more detail, FIG. **7**B shows an exploded view of FIG. **7**A with a fluid interface body **201** comprising a rigid base with protruding rings **202** on a second side **215** and hose barbs **203** on a first side **214**. Openings **204** inside the protruding ring **202** and inside the barb **203** result combine to form an internal conduit **210** connecting the ring **202** to the barb **203**. Attached to the top surface of the fluid interface body **201** is a fluid interface gasket **205** comprising holes located at the positions of the protruding rings **202**. Under pressure, the gasket **205** is compressed onto the rings **202** on the fluid interface **201** top surface resulting in a leak free seal of the ring **202**. In one embodiment, fluid is delivered from a conduit **206** connected to the barb **203** through the opening **204** in the protruding ring and out of the corresponding opening **217** in the gasket **205**. In another embodiment, a direct tube **207** can be inserted through the opening **230** in the fluid interface body **201** and the opening **231** in the fluid interface gasket **205** such that fluid is delivered through the direct tube **207** rather than directly contacting a conduit **210** in the fluid interface body **201**. In this embodiment, the direct tube **207** exiting from the gasket hole **217** can be flared **208** to aid in sealing the direct tube **207** to an external surface.

In even more detail, FIG. **7**B shows an exploded view of a fluid interface body **201** for interfacing with fluid bottles to fluid devices. The fluid interface body **201** comprises hose barbs **203** for connecting tubing **206** to flat surfaces of fluid devices. The side **215** of the fluid interface **201** which interfaces with the fluid device comprises protruding rings **202** such that compression of a fluid interface gasket **205** between the fluid interface **201** and the fluid device forms a leak free seal around the ring **202**. Reducing the surface area of contact by using a ring **202**, or any small surface area structure slightly larger than the opening **204** allows for more compression of the fluid interface gasket **205**. This compression seal places the conduit **210** within the fluid interface body in fluid communication with the microreactor device **706**. This creates a path from an external conduit **206** to the microreactor device.

Further detail is provided for FIG. 7B. The fluid interface body **201** can be made of any material that can be sterilized by any one of many conventional sterilization methods such as but not limited to autoclave, gamma irradiation, or ethylene oxide such as but not limited to polycarbonate, polysulfone, radel, polypropylene, aluminum, steel, copper, or brass. The fluid interface body **201** can be between 0.01 and 3 inches or less than 12 inches long, between 0.01 and 3 inches or less than 12 inches wide, and between 0.01 and 3 inches or less than 12 inches thick. Protruding rings **202** can be greater than 0.001 inches or between 0.001 and 0.04 inches high and less than the smaller of the length and width of the fluid interface **201** in diameter. openings **204** in the protruding rings **202** are of smaller diameter than the protruding ring **202**. Hose barbs **203** can be between 0.03125 inch and 0.25 inch in diameter with holes **204** of lesser diameter and less than 0.5 inch in height or between 0.03125 inch and 0.25 inch in height. The fluid interface gasket **205** made of an elastic material such as but not limited to silicone, butyl rubber, EPDM, or viton. Fluid interface gaskets **205** can have length and width of thickness between 0.01 and 0.25 inch. The conduit **206** or direct tube **207** inserted into openings **204** or into barbs **203** of the fluid interface body **201** can be made of plastic or rubber such as viton, tygon, PVC, teflon, BPT, or any other material which is suitable for use with liquids and can be sterilized by any of the sterilization methods known to those with ordinary skill in the art. Conduit **206** and direct tube **207** can be of outer diameter between 0.01 inch and 0.5 inch. For direct tube **207** which has a flare **208**, the flare **208** can be between 1% to 1000% larger than the outer diameter of the direct tube **207**.

FIG. **8**A shows an assembled view of a fluid interface body **201**, fluid interface gasket **205**, and conduits **206** connected to a microreactor device **706**. In more detail FIG. **8**B shows an exploded view of a fluid interface body **201**, fluid interface gasket **205**, and conduit **206** connected to a microreactor device **706**. The surface **305** of the microreactor device **706** which contacts the fluid interface gasket **205** comprises protruding rings **306** on the microreactor device **706** that have minimal surface area to increase deformation of the fluid interface gasket **205**. For connections where fluid is delivered through a direct tube **207**, the protruding ring **308** on the microreactor device **706** is of larger surface area than the tube flare **208** such that the tube flare **208** makes contact with the protruding ring **308** of the microreactor device **706**. In this configuration, the dimensions are designed such that the fluid interface gasket **205** compresses into the tube flare **208** and seals the tube flare **208** to the protruding ring **308**. When aseptic sterile fluid connections are necessary between the fluid interface body **201**, fluid interface gasket **205**, and microreactor device **706**, sections which are sterilized and exposed to air can be protected with peelable adhesive liners using methods such as U.S. Pat. No. 3,865,411 or others known to those with ordinary skill in the art. It should be understood that the protruding rings **306** and **308** encircle openings from the second group **768** of openings in the microreactor device **706**.

Referring in more detail to FIG. **8**B, the surface **305** of the microreactor device **706** is of similar or larger size than the fluid interface body **201** or fluid interface gasket **205**. In a preferred embodiment, the contact surface **305** of the microreactor device **706** has an area of 0.3 square inches or between 0.05 square inches and 5 square inches. The microreactor device **706** can be made of plastic, metal, or any other material which is of higher rigidity than the fluid interface gasket **205** such as but not limited to polycarbonate, acrylic, polysulfone, radel, polypropylene, aluminum, steel, copper, or brass and can be sterilized by any of the sterilization methods known to those with ordinary skill in the art. The protruding rings **306**, **308** of the microreactor device **706** can be greater than 0.001 inches or between 0.001 and 0.04 inches high and between 0.02 inch and 0.1 inch in width or less than the smaller of the length and width of the fluid interface body **201** in diameter. The openings from the group **768** surrounded by protruding rings **306**, **308** are of smaller diameter than the protruding rings **306**, **308**.

FIG. **9**A shows a top view of the pressure connector and the location of the cross-section **405** for FIG. **9**B.

FIG. **9**B shows a cross-section view of a pressure connector **401**. The pressure connector comprises at least two barbs **402** to interface with tubing and a first conduit **403** and second conduit **406** respectively connecting the openings **407** and **404** and the openings **409** and **408**. The pressure connector **401** allows two or more fluid or gas sources entering from the barbs openings **409** and **407** to be connected together when the openings **408** and **404** are in fluid communication through an enclosed external structure.

In more detail, the pressure connector **401** in FIG. **9**B can be made of a rigid material such as but not limited to polycarbonate, acrylic, polysulfone, radel, polypropylene, aluminum, steel, copper, or brass. The pressure connector **401** can be 0.375 inch in diameter or between 0.05 and 5 inch in diameter or if the pressure connector **401** is not round but another smooth shape, can be 0.375 inch in its maximum width or between 0.05 and 10 inch in its maximum width. The pressure connector can be 1 inch long or between 0.15 inch and 5 inch long. Hose barbs **402** can be added as external components or can be part of the pressure connector **401**. Hose barbs **402** can be 0.1 inch in outer diameter or between 0.02 and 1 inch in outer diameter.

FIG. **10**A shows a partial top view of a microreactor controller including a pressure interlock and fluid interface assembly with a section line **501**. FIG. **10**B shows a cross section view of the pressure interlock and fluid interface assembly in a pressurized configuration along the section line **501** in FIG. **10**A.

A clamp **503** applies pressure to the fluid interface **200** and microreactor device **706** and compresses the fluid interface gasket **205** to form a leak free seal. The clamp **503** comprises one or more springs **506** which apply force to the base **504** of the clamp **503** and a pivot point **507** such that the spring force is translated to press the microreactor device against the fluid interface gasket **205**. The housing **508** provides the support to the pivot point **507** preventing the upper portion of the clamp **503** from lifting. The clamp housing **508** also supports the clamp base **504** such that the clamp **503** is allowed to move with respect to the microreactor device **706**. Other methods of implementing a way to compress the fluid interface gasket **205** between the fluid interface body **201** and microreactor device **706** are also possible, such as but not limited to using springs or screws. Once the clamp **503** is in place, the pressure connector **401** and structural panel **511** can be used to secure the clamp **503** in place. The structural panel **511** comprises a cavity **512** with seals **513** such that a connector **401** of appropriate diameter inserted into the cavity **512** will result in an air tight seal in the volume between the seals **513** of the housing **511**. In addition, the structural panel **511** can be attached to the clamp housing **508** to align the pressure connector **401** and the clamp **503**. When the pressure connector **401** is pushed towards the clamp **503**, and the openings **404** and **408** are between the two seals **513**, the first conduit **403** and second conduit **406** in the pressure connector **401** are in fluid communication. In this configuration, the pressure connector **401** can physically stop the clamp **503** from being removed from the device **706**. Therefore if the conduits **403** and **406** of the pressure connector **401** are in fluid communication, the device **706** cannot be disconnected from the fluid interface **200**. If desired, a locking mechanism **515** can also be used to lock the pressure connector **401** in place when pushed against the clamp **503**. This will further prevent the microreactor device **706** from being disconnected from the fluid interface **200** before the conduits **403** and **406** in the pressure connector **401** are disconnected. If this were not the case, a pressure or fluid connection could be active when the microreactor device **706** is disconnected from the fluid interface **201** and fluid or gas could leak into undesired locations.

FIG. **10**C and FIG. **10**D show the two configurations of the pressure connector **401** in more detail.

The disconnected position depicted in FIG. **10**C shows that the opening **404** of conduit **403** is between the seals **513**. The opening **408** of conduit **406** is outside of the seals **513** and is open to atmosphere. In this configuration, conduit **403** and **406** are not in fluid communication within the cavity **512** and a pressure in conduit **403** is not transmitted to the conduit **406**. In the configuration shown in FIG. **10**C with the opening **404** between the seals **513**, if a pressure source **912** is in fluid communication with conduit **403**, the cavity **512** reaches the same pressure as the pressure source **912** and there is no airflow. If both openings **408** and **404** were outside of the seals **513**, for example by pulling the pressure connector **401** further away from the clamp **503**, the conduits **406** and **403** would still not be in fluid communication with the cavity **512** and a pressure in conduit **403** would not be transmitted to conduit **406**, however the pressure source **912** (shown in FIG. 2B) would then be vented to atmosphere. When the pressure connector is in a position such that at least one of conduits **406** and **403** is vented, therefore depressurizing the fluid sources from the fluid interface **200**, there is sufficient space for clamp **503** to be removed and the microreactor device **706** can be removed without excessive fluid leaking from the fluid interface **200**.

While the design of the pressure connector **401** comprises two conduits, **403** and **406** which are interconnected when sealed inside the cavity **512** between the seals **513**, the pressure connector **401** can contain more or less channels, for example if multiple connections are desired when locked, or if conduits connected to the sealed cavity **512** exist in the structural panel **511** rather than in the pressure connector **401**.

Referring in more detail to FIG. **10**B, the clamp **503** is a nominally rigid material such as but not limited to polycarbonate, polypropylene, acrylic, aluminum, copper, brass. The outer dimensions of the clamp **503** are similar to those of the fluid interface **201** and can be between 0.01 and 3 inches or less than 12 inches long, between 0.01 and 3 inches or less than 12 inches wide, and between 0.01 and 3 inches or less than 12 inches thick. Springs **506** are capable of supplying between 0.1 and 100 pounds of force and can be compression springs or spring pins made of materials such as but not limited to steel, stainless steel, bronze, brass, acetal, or nylon. The pivot point **507** can be made of a nominally rigid material such as but not limited to acrylic, aluminum, or steel, such that the yield strength of the pivot point **507** is greater than the spring force of the springs or can be part of the clamp **503** material. The pivot point **507** can be a rod or bar 0.0625 inches in width or between 0.02 and 1 inch in width and can extend from the clamp surface by 0.1 inches or between 0.02 and 1 inch. The clamp housing **508** can also be made of a nominally rigid material such as but not limited to polycarbonate, polypropylene, acrylic, aluminum, copper, brass. The housing **508** dimensions are larger than the clamp **503** dimension such that the clamp **503** can restricted by the housing **508**. For example the housing **508** can be between 0.1 and 10 inches larger in length, width, and or height of the clamp **503**.

In further detail, in a preferred embodiment shown in FIG. **10**B, the structural panel **511** is of similar size to the clamp housing **508** to allow the structural panel **511** to attach to the clamp housing **508**. While this is the case in a preferred embodiment, similar size is not necessary as the attachment can occur through screws, clamps, bolts, or the like and would only be restricted in size by the mechanism of attachment. The structural panel **511** can be made of any rigid material such as but not limited to polycarbonate, polypropylene, acrylic, peek, Teflon, aluminum, copper, brass, or iron. The seals **513** in the interfacing structural panel can be o-rings or another seal made of an elastomer or rubber material such as but not limited to silicone, butyl rubber, EPDM, or viton and can be between 0.02 and 1 inch in thickness and 0.4 inches or between 0.01 and 4 inches in diameter such that the pressure connector can be sealed by the seals.

FIG. **11**A shows a top view of a fluid bottle **1001** and a dotted line indicates a section-line **1002**. FIG. **11**B is a side view cross section of FIG. **11**A along the section line **1002** which shows that the bottle cap **1003** comprises an insert **1004** for tubing connections. The insert **1004** comprises inside barbs **1005** and outside barbs **1009** for tubing on both sides such that a tubing connection can be made from outside the fluid bottle **1001** to the bottom of the fluid bottle **1001**. While not shown in FIG. **11**A, but illustrated schematically in FIG. **2**B, a desired tubing connection would be from the external hose barb **1009** to the fluid interface **200** conduit **206**. The insert **1004** also comprises a ring **1007** of smaller perimeter than the opening of the fluid bottle and an o-ring **1008** outside of the ring **1007** to enable a seal between the insert **1004** and the fluid bottle **1001**. The fluid bottle cap **1003** comprises a hole for the insert **1004** and the insert **1004** is sealed against the fluid bottle **1001** by screwing on the cap **1003**. An insert **1004** and bottle **1001** configured in this way allows a fluid bottle **1001** to be sealed with defined inputs and outputs from the bottle **1001**.

Referring in more detail to FIG. **11**B, the fluid bottle **1001** is a bottle which can be autoclaved, such as a glass or polypropylene bottle, with a cap made of a rigid sterilization stable plastic or metal such as but not limited to polypropylene, polycarbonate, aluminum, or brass. In a preferred embodiment, fluid bottles **1001** can be commercial bottles such as those purchased from companies such as VWR or Nalgene. The insert **1004** is also made of a rigid sterilization stable plastic or metal such as but not limited to polypropylene, polycarbonate, aluminum, or brass. The o-ring **1008** of the insert **1004** is made of an elastomer or rubber material such as but not limited to silicone, butyl rubber, EPDM, or viton. The insert **1004** can be 5% smaller in diameter or between 1% and 50% smaller than the bottle cap **1003**. The insert **1004** can contain 3 hose barbs **1005**, or between 1 and 64 hose barbs **1005**. The hose barbs **1005** can be added as external components or can be part of the insert **1004**. Hose barbs **1005** can be 0.1 inch in outer diameter or between 0.02 and 1 inch in outer diameter **1005**.

EXAMPLES

Examples of preferred embodiments are described herein.

An example apparatus **601** to operate a microreactor device **706**, the microreactor device **706** having a first side **761** and a second side **762**, said first side **761** having a first opening **765** among a first group of openings **767** for air pressure, and a second opening **766** among a second group of openings **768** for liquids, the apparatus comprised: a middle heater **801**; a heated base plate manifold **800**, formed by bonding together base plate top **802** and base plate bottom **803**, comprised a thermally conductive material, such as aluminum, that was in thermal communication with the middle heater **801**, a conduit **805** with a first opening **810** that was on a first substantially planar surface **812** of the base plate and a second opening **811** that was on a second substantially planar surface of the base plate **813**, said second opening was in fluid communication with the first opening **765** of the microreactor device **706**; a first pressure source **910**; a reservoir, comprised a thermally conductive reservoir layer **901** bonded to another reservoir capping layer **902**, the thermally conductive reservoir layer **901** was in thermal communication with the heated base plate manifold **800** and was in fluid communication with the first pressure source **910**; a solenoid switch **904** with a first port that was in fluid communication with the first opening **810** of the conduit **805** and a second port that was in fluid communication with the humidifier reservoir **900**; and a top heater **101** that was in thermal communication with the second side **762** of the microreactor.

For this example, the microreactor device was operated by switching the pneumatic pressures in a series of openings in the device to, for example, open and close various valves or to actuate mixing structures. It was preferred to use a humidified gas to deliver the pneumatic pressures to minimize evaporation in the microreactor device. This was accomplished by heating the source gas in the presence of liquid water in a reservoir. The flow of humidified gas was controlled by a solenoid switch. To maintain the humidity of the gas and to prevent condensation of the humidified gas, the temperature of the conduit and the temperature of the microreactor device were maintained above the condensation threshold. This was accomplished by delivering the humidified gas to the microreactor device through a conduit in the heated base plate and also by heating the microreactor device on its top and bottom side. Maintaining the top heater temperature higher than the bottom heater temperature ensured condensation free operation. The heated base plate was fabricated by machining channels into an aluminum plate **803** and bonding it to another aluminum plate **802**. Holes at the endpoints of the channels **805** that were on the top plate, but could have either on the top plate or the bottom plate, completed the conduits through the base plate. The humidification reservoir was similarly fabricated by bonding an aluminum plate with machined cavities to a flat plate to form an enclosed volume. Various holes provided access to the volume to introduce water for humidification and a source of air pressure. This humidified gas was routed through a manifold to the appropriate ports of solenoid switches which alternately connected each conduit in the top plate with the humidified pressure reservoir, or vented the conduit to atmosphere. It should be clear to those of ordinary skill in the art how this example was constructed or similar apparatus may be constructed using conventional manufacturing techniques such as machining and bonding.

An example for mounting the microreactor device **706** in a way to place the first opening of the microreactor **765** in fluid communication with the second opening **811** of the base plate **800** used an aligner, comprised, for example, two cylindrical posts **830** in the base plate that mated with two holes **769** in the microreactor device to mechanically constrain the position of the microreactor with respect to the base plate so the opening in the microreactor **765** was aligned with the second opening **811** of the base plate; a first gasket **815** that was in contact with the second surface of the base plate **813**, said first gasket **815** had an opening **817** coincident with the second opening **811** of the base plate **800**; and a clamp **503** that secured the first side of the microreactor device in a fixed position relative to the second substantially planar surface of the base plate **813** such that the first opening **765** on the first side **761** of the microreactor device was in fluid communication with the second opening **811** of the conduit in the base plate through the opening in the first gasket.

Using this example, a large number of openings which corresponded to valves or other pressure driven structures, were aligned to a large number of conduits **805** in the base plate **800**. The first gasket **815** conformed to the second substantially planar surface **813** of the base plate and the first surface **761** of the microreactor and formed a seal. The clamp **513**, or in general two clamps served to provide a force to hold the microreactor onto the gasket, and maintained the seal. To be precise, the clamps held the microreactor device in a fixed position relative to the substantially planar surface of the base plate which allowed for other components, such as a thin middle heater **801** to be placed between the microreactor **706** and the base plate **800**. The term substantially planar is used to allow for surface relief features in the base plate or the microreactor device.

In addition to operating a microreactor device with a pressurized gas under conditions to minimize evaporation from the microreactor device and to minimize condensation in the microreactor device, it was preferred to also exchange liquids with the microreactor device. In particular for certain applications such as conducting bioreactions, it was preferred to exchange liquids with the microreactor device aseptically. To deliver fluids aseptically, all surfaces that contacted the fluid were sterilized. This was accomplished by autoclaving or gamma irradiating, although a variety of other options including dry heat, steam heat, ethylene oxide gas, or other methods to kill potential contaminants could have been used. For preferred embodiments of the invention, the microreactor device was sterilized using gamma irradiation and packaged aseptically. To avoid sterilizing the entire microreactor controller **601** it was preferable to have a removable fluid delivery subsystem that was sterilized separately from the microreactor controller. One embodiment, among many, was a rack of bottles with conduits connected to a fluid interface which were efficiently coupled to the microreactor device. Aseptic coupling was accomplished by covering the liquid openings **768** on the microreactor device and the openings of the fluid interface gasket **217** with sterilizable tape. It should also be noted that to maintain sterility the gasket **205** was bonded to the fluid interface body **201** using an adhesive tape. Also, during autoclave of the fluid interface, mechanical pressure was applied to the tape using a standard binder clip to prevent the tape from debonding during autoclaving. The sterilizable tape was attached to pull tabs that were used to remove the sterilizable tape for the microreactor and the fluid interface simultaneously, in a way known in the art and described in U.S. Pat. No. 3,865,411, when the microreactor device and the fluid interface were held together manually just prior to clamping.

An example embodiment comprised the elements described in previous paragraphs to interface a microreactor to humidified pneumatic signals and further comprised: a fluid interface **200** to exchange a fluid between an external source and the microreactor device, said fluid interface comprised: a body **201** which comprised a conduit **210** with a first opening **212** and a second opening **213** on a surface **215** of the body; a conduit **206** that was in fluid communication with the first opening of the body; and a second gasket **205** that was in contact with the second surface **215** of the body, said second gasket **205** had an opening **217** that coincided with the second opening **213** of the body. A cavity **820** in the base plate **800** allowed mounting the fluid interface, **200** such that the gasket of the fluid interface was approximately parallel to the second substantially planar surface of the base plate so the microreactor device **706** could be sealed to both the first gasket **815** and fluid interface gasket **205**. An aligner in the form of two alignment posts **220** on the fluid interface mating with two holes **832** in the base plate cavity **820**, mechanically constrained the fluid interface with respect to the base plate. The alignment of the fluid interface with the base plate ensured when the microreactor was aligned to the base plate all openings on the microreactor were aligned with their corresponding openings of the base plate and fluid interface. The clamp **503** closest to the fluid interface was configured in a first position that secured the microreactor device to the gaskets. The clamp **503** also had a second position which allowed the microreactor to be removed from the base plate.

Means to deliver liquids to microreactor devices are known in the art. One example was to use liquid flow from a pressure difference from the source to the destination where a liquid from a reservoir was provided under pressure and the flow of liquid was controlled in the microreactor using valves. One embodiment was to use a container, such as a bottle **1001** with a cap **1003** and insert **1004** that provided an air tight seal but for three openings, one used to fill the bottle with liquid **1032**, another used to draw liquid from the bottle **1012**, and another used to pressurize **1022** the headspace **1010** of the bottle which provided a driving pressure for the liquid. A conduit **1006** with one end in communication with the opening **1012** and the other end at the bottom of the bottle permitted fluid to leave the bottle through the opening **1012** when the headspace **1010** was pressurized. Typically, the opening **1012** was connected to a conduit **206** with a distal end connected to an opening **212** of the fluid interface.

It was a preferred embodiment to provide a pressure interlock to prevent decoupling of the microreactor from the fluid interface while the bottles were pressurized. Otherwise, if the microreactor were decoupled while the bottles **1001** were still under pressure, liquid would have been forced from the fluid interface and made undesirable contact with other surfaces. In a preferred embodiment, this function was provided by a pressure interlock whereby a mechanical component was configured to connect a pressure source to a bottle headspace and also blocked the removal of a clamp that held the microreactor **706** and fluid interface **200** together.

A preferred embodiment of a pressure interlock comprised: a structural panel **511** with a first fixed position with respect to the first position of the clamp **503**; a cavity **512** within the structural panel with a first opening **520** that was on a first side **522** of the structural panel and a second opening **521** that was on a second side **523** of the structural panel **512**, said openings had the same cross section and were aligned such that a prism with the same cross section as the opening, but scaled by 0.99 would pass through both openings; a seal **513** that was at the first opening **520** and a seal **513** that was at the second opening **521** allowed that the insertion of a prism with cross section approximately equal to the cross section of the first opening formed an enclosed volume inside the structural panel; a pressure connector **401**, that was in the shape of a prism with cross-section approximately the same as the first opening **520** of the cavity, comprised a first conduit **403** with a first opening **404** that was on a radial face of the pressure connector and a second opening **407** that was on a face of the pressure connector, which was preferably at the end of a hose barb **402** that was in fluid communication with a second pressure source **912** and comprised a second conduit **406** with a first opening **408** that was on the radial face of the pressure connector and a second opening **409** that was on a face of the pressure connector, said second opening **409** was in fluid communication with the inlet **1022** of the container; a first axial position (FIG. **10**B) of the pressure connector where the first conduit **403** within the pressure connector and second conduit **406** within the pressure connector were in fluid communication within the cavity **412** and where an axial face **421** of the pressure connector constrained the clamp **503** in the first position; a second axial position (FIG. **10**C) of the pressure connector where the first conduit within the prism was not in fluid communication, within the cavity, with the second conduit within the prism; and a second pressure source **912** that was in fluid communication with the second opening **407** of the first conduit **403** within the pressure connector **401**.

Example methods using the apparatus described in previous examples included a first example method that comprised the steps where: the temperature of the base plate was controlled to a first temperature range T**1**; the temperature of the top heater was controlled to a second temperature range T**2**; and the solenoid switch was opened and closed. Condensation within the microreactor devices **706** was minimized by setting the first temperature range T**1** lower than the second temperature range T**2**.

A second example method comprised the steps where: the fluid interface was inserted and aligned into the cavity; the microreactor was aligned to the base plate using an aligner; and the clamp was configured in the first position which sealed the device to the gasket of the fluid interface.

A third example comprised the steps where: a container, conduits in fluid communication with the container, a fluid interface, and a first sterilizable tape covering the openings of the fluid interface were sterilized; the container was filled with sterilized fluid; the fluid interface **200** was inserted and aligned to a cavity in a base plate **820**; the sterilized microreactor device with a second sterilizable tape which contacted the first surface of the first sterilizable tape with the first surface of the second sterilizable tape was aligned to the base plate; the first and second sterilizable tape was simultaneously removed; and a clamp was configured in a first position that sealed the microreactor device to a gasket of the fluid interface.

A fourth example comprised the steps where: a container, conduits in fluid communication with the container, a fluid interface, and a first sterilizable tape covering the openings of the fluid interface were sterilized; the container was filled with sterilized fluid; a pressure connector was configured to a second axial position, and then a fluid interface was inserted into the cavity of a base plate and then the structural panel was fixed in its first position and then the microreactor device was aligned to the base plate with an aligner, and then the first surface of the first sterilizable tape was contacted to the first surface of the second sterilizable tape, and then the first and second sterilizable tape were simultaneously removed, and then the clamp was configured in the first position, and then the pressure connector was configured in the first axial position.

Definitions

Microreactor: This term refers to miniature devices with spatial dimensions many times smaller than the analogous macroscopic system. Exemplary microreactor devices may have two spatial dimensions on the order of 100 microns or 10 cm and a third spatial dimension on the order of 1 micron or 1000 microns. A microreactor generally may serve different purposes, such as a microreactor for performing a chemical reaction, or a microreactor for performing a fermentation or cell culture, otherwise known as a microbioreactor. Such microreactors may be housed or supported by a larger physical structure, such as a block of plastic measuring 2 inches by 3 inches by 0.5 inches.

Substantially planar: This term refers to a geometry where a third spatial dimension is less than 10 percent of the other two spatial dimensions. An example would be a 3 inch by 4 inch plate with channels less than 0.3 inches deep, or ridges less that 0.3 inches high.

solenoid switch: This term refers to electro mechanical devices used to switch the flow of a fluid between one or more ports. A port refers to an opening on the surface of a face of the solenoid switch, or a conduit within the solenoid switch. An example is a 3-way solenoid switch with one common port, a normally closed port, and a normally open port. When the solenoid is not energized, the common port is in fluid communication with the normally open port and not in fluid communication with the normally closed port. When the solenoid is energized, the common port is in fluid communication with the normally closed port and not in fluid communication with the normally open port.

aligner: This term refers to a mechanical structure used to align one part with another part. One example is a pair o pins, or protruding cylinders in one part and a pair of holes or circular openings in another part. The diameter of each hole would be chosen such that the hole would fit over the corresponding pin, yet constrain the lateral motion of the parts with respect to each other. An example of a pin-hole pair is a pin with 0.0625 inch diameter and a hole 0.0635 inches. In general an aligner comprises multiple mechanical features such as multiple holes and multiple pins. The position of the holes and pins are chosen such that, for example, when the holes and pins are aligned, the first opening of the microreactor device is aligned to the opening of the first gasket and the second opening of the microreactor device is aligned to the opening of the second gasket and more generally, openings of the microbioreactor are aligned to openings in the heated base plate manifold or fluid interface connector.

fluid: This term refers in general to a liquid or a gas.

manifold: This term refers to an object comprising an internal fluid conduit, preferably an object comprising a plurality of internal fluid conduits, with openings to supply or remove fluid from the conduits.

prism: This term refers to an object with constant cross-section. It can be defined by a two dimensional cross-section determined by a closed curve and a length orthogonal to the cross section. For example, a cylinder with circular cross section.

cross-section of an opening approximately equal to the cross section of a prism: In this relationship the term approximately equal is used to allow for the prism to be slightly smaller than the opening so the prism may to pass through the opening. At the same time, the size and shape of the prism cross-section should be similar enough to the opening to facilitate sealing the opening against the prism with a seal. An example would be a 0.375 inch diameter opening in a 0.50 inch thick plate and a 0.370 inch diameter cylinder. Two seals with inner diameter 0.365, residing in two o-ring grooves on either side of the opening would seal against the cylinder inserted through the opening.

conduit: This term refers in general to enclosed fluid flow paths such as a tube, or pipe, or buried channel suitable for transporting fluid from one location to another.

pressure source: This term refers to a container with a gas maintained in a specified pressure range such as the storage tank of an air compressor, or more generally the storage tank and any conduits connected to said storage tank.

structural panel: This term refers to a solid material used to provide support for components. A structural panel may also have features such as cavities or channels to provide additional functionality. For example, in a preferred embodiment, a structural panel is a one half inch thick piece of polycarbonate, approximately 4 inches by 6 inches in lateral dimensions comprising a cavity and openings to accommodate the prism. In addition, a preferred embodiment of a structural panel has rectangular cutout and grooves to accommodate various conduits.

Thus, specific compositions and methods of a system and methods to operate microreactor devices have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the disclosure.

Moreover, in interpreting the disclosure, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

Having thus described the invention, what is claimed as new and secured by letters patent is:

1. An apparatus to operate a microreactor device, the microreactor device having a first side and a second side, said first side having a first opening and a second opening, the apparatus comprising:

a first heater;

a base plate, in thermal communication with the first heater, comprising: a thermally conductive material; and a control conduit with a first opening on a first substantially planar surface of the base plate and a second opening on a second substantially planar surface of the base plate, said second opening in fluid communication with the first opening of the microreactor device, wherein at least a portion of the length of the control conduit runs laterally across the base plate;

a first pressure source;

a reservoir, comprising a thermally conductive material, in thermal communication with the base plate and in fluid communication with the first pressure source;

a vent conduit;

a 3-way solenoid switch comprising a first port in fluid communication with the first opening of the control conduit; a second port in fluid communication with the reservoir; and a third port in fluid communication with the vent conduit, wherein the 3-way solenoid switch in an on-state fluidically connects the first port and the second port and fluidically isolates the third port, and the 3-way solenoid switch in an off-state fluidically connects the first port and the third port and fluidically isolates the second port; and

a second heater in thermal communication with the second side of the microreactor device.

2. The apparatus of claim **1** wherein the first substantially planar surface of the base plate and the second substantially planar surface of the base plate are the same surface.

3. The apparatus of claim **1** further comprising:

a hinged lid;

a spring pin protruding from the hinged lid;

an extension spring;

wherein the second heater is held against the spring pin by the extension spring; and a top aligner to align the second heater to the microreactor device.

4. The apparatus of claim 3 further comprising:

a light emitting diode;

a waveguide; and

a photodiode.

5. The apparatus of claim 1 further comprising:

a control gasket in contact with the second surface of the base plate, said control gasket having an opening coincident with the second opening of the control conduit in the base plate;

a bottom aligner to align the microreactor device to the base plate; and

a clamp to secure the first side of the microreactor device in a fixed position relative to the second substantially planar surface of the base plate such that the first opening on the first side of the microreactor device is in fluid communication with the second opening of the control conduit in the base plate through the opening in the control gasket.

6. The apparatus of claim 1 further comprising:

a control gasket in contact with the second surface of the base plate, said control gasket having an opening coincident with the second opening of the control conduit in the base plate;

a fluid interface to exchange a fluid between an external source and the microreactor device, said fluid interface comprising: a fluid interface body comprising a feed conduit with a first opening and a second opening on a surface of the body; a source conduit in fluid communication with the first opening of the body; and a fluid interface gasket in contact with the surface of the body, said fluid interface gasket having an opening coinciding with the second opening of the body;

a cavity in the base plate such that when the fluid interface body is mounted in the base plate, the fluid interface gasket of the fluid interface is approximately parallel to the second substantially planar surface of the base plate;

an aligner to align the fluid interface to the base plate;

an aligner to align the microreactor device to the base plate; and

a clamp with a first position that secures the first side of the microreactor device in a fixed position relative to the second substantially planar surface of the base plate, and a second position which allows the removal of the microreactor device from the control gasket and fluid interface gasket.

7. The apparatus of claim 6 further comprising:

a first sterilizable tape with a first surface covering the opening of the fluid interface gasket of the fluid interface; and

a second sterilizable tape with a first surface covering the second opening of the microreactor device.

8. The apparatus of claim 7 further comprising:

a container with an inlet and an outlet; and

a bottle conduit with a first end in fluid communication with the outlet of the container and a second distal end in fluid communication with the inside of the container;

wherein the source conduit of the fluid interface is in fluid communication with the outlet of the container.

9. The apparatus of claim 8 further comprising:

a structural panel with a first fixed position with respect to the first position of the clamp;

a cavity within the structural panel with a first opening on a first side of the structural panel and a second opening on a second side of the structural panel, said openings having the same cross section;

a seal at the first opening and a seal at the second opening such that insertion of a prism with cross section approximately equal to the cross section of the first opening forms a volume inside the structural panel;

a pressure connector in the shape of a prism with cross-section approximately the same as the first opening of the cavity, comprising a first prism conduit with a first opening on a radial face of the pressure connector and a second opening on a face of the pressure connector, and comprising a second prism conduit with a first opening on the radial face of the pressure connector and a second opening on a face of the pressure connector, said second opening of the second prism conduit in fluid communication with the inlet of the container;

a first axial position of the pressure connector where the first prism conduit and second prism conduit are in fluid communication within the structure panel cavity and where an axial face of the pressure connector constrains the clamp in the first position of the clamp;

a second axial position of the pressure connector where the first prism conduit is not in fluid communication within the structure panel cavity with the second prism conduit within the pressure connector; and

a second pressure source in fluid communication with the second opening of the first prism conduit.

10. The apparatus of claim 9 further comprising:

a hinged lid;

a spring pin protruding from the hinged lid;

an extension spring;

the heater held against the spring pin by the extension spring;

an aligner to align the heater to the microreactor device;

a light emitting diode;

a waveguide; and

a photodiode.

11. A method for operating an apparatus to operate a microreactor device, the apparatus comprising:

a first heater;

a base plate, in thermal communication with the first heater, comprising: a thermally conductive material; and a control conduit with a first opening on a first substantially planar surface of the base plate and a second opening on a second substantially planar surface of the base plate, said second opening in fluid communication with the first opening of the microreactor device, wherein at least a portion of the length of the control conduit runs laterally across the base plate;

a first pressure source;

a reservoir, comprising a thermally conductive material, in thermal communication with the base plate and in fluid communication with the first pressure source;

a vent conduit;

a 3-way solenoid switch comprising a first port in fluid communication with the first opening of the control conduit; a second port in fluid communication with the reservoir; and a third port in fluid communication with the vent conduit, wherein the 3-way solenoid switch in an on-state fluidically connects the first port and the second port and fluidically isolates the third port, and the 3-way solenoid switch in an off-state fluidically connects the first port and the third port and fluidically isolates the second port; and

a second heater in thermal communication with the second side of the microreactor device;

the method comprising the steps:

controlling the temperature of the base plate to a first temperature range T1;

controlling the temperature of the second heater to a second temperature range T**2**; and

opening and closing the solenoid switch.

12. The method of claim **11** further comprising the step: controlling the temperature of the reservoir to a third temperature range T**3**.

13. The method of claim **11** further comprising the step: introducing a fluid into the reservoir.

14. The method of claim **11** where the temperature ranges are constrained such that:

the first temperature range T**1** is less than or equal to the second temperature range T**2**.

15. The method of claim **12** where the temperature ranges are constrained such that:

the first temperature range T**1** is less than or equal to the second temperature range T**2**; and

the first temperature range T**1** is greater than or equal to the third temperature range T**3**.

16. The method of claim **11** where the apparatus to operate a microreactor device further comprises:

a control gasket in contact with the second surface of the base plate, said control gasket having an opening coincident with the second opening of the control conduit in the base plate;

a fluid interface to exchange a fluid between an external source and the microreactor device, said fluid interface comprising: a fluid interface body comprising a feed conduit with a first opening and a second opening on a surface of the body; a source conduit in fluid communication with the first opening of the body; and a fluid interface gasket in contact with the surface of the body, said fluid interface gasket having an opening coinciding with the second opening of the body;

a cavity in the base plate such that when the fluid interface body is mounted in the base plate, the fluid interface gasket of the fluid interface is approximately parallel to the second substantially planar surface of the base plate;

an aligner to align the fluid interface to the base plate;

an aligner to align the microreactor device to the base plate; and

a clamp with a first position that secures the first side of the microreactor device in a fixed position relative to the second substantially planar surface of the base plate, and a second position which allows the removal of the microreactor device from the control gasket and the fluid interface gasket;

the method further comprising the steps:

inserting the fluid interface into the cavity of the base plate;

aligning the first opening of the microreactor device to the opening of the control gasket and aligning the second opening of the microreactor device to the opening of the fluid interface gasket; and

configuring the clamp in the first position.

17. The method of claim **16** where the apparatus to operate a microreactor further comprises:

a first sterilizable tape with a first surface covering the opening of the fluid interface gasket of the fluid interface; and

a second sterilizable tape with a first surface covering the second opening of the microreactor device;

a container with an inlet and an outlet; and

a bottle conduit with a first end in fluid communication with the outlet of the container and a second distal end in fluid communication with the inside of the container;

wherein the source conduit of the fluid interface is in fluid communication with the outlet of the container;

the method further comprising the steps:

sterilizing the container, the conduits in fluid communication with the container, the fluid interface, and the first sterilizable tape;

filling the container with sterilized fluid;

inserting the fluid interface into the cavity of the base plate;

aligning the first opening of the microreactor device to the opening of the control gasket and aligning the second opening of the microreactor device to the opening of the fluid interface gasket;

contacting the first surface of the first sterilizable tape with the first surface of the second sterilizable tape;

simultaneously removing the first and second sterilizable tape; and

configuring the clamp in the first position of the clamp.

18. The method of claim **17**, the apparatus to operate a microreactor device further comprising:

a structural panel with a first fixed position with respect to the first position of the clamp;

a cavity within the structural panel with a first opening on a first side of the structural panel and a second opening on a second side of the structural panel, said openings having the same cross section;

a seal at the first opening and a seal at the second opening such that insertion of a prism with cross section approximately equal to the cross section of the first opening forms a volume inside the structural panel;

a pressure connector in the shape of a prism with cross-section approximately the same as the first opening of the cavity, comprising a first prism conduit with a first opening on a radial face of the pressure connector and a second opening on a face of the pressure connector, and comprising a second prism conduit with a first opening on the radial face of the pressure connector and a second opening on a face of the pressure connector, said second opening of the second prism conduit in fluid communication with the inlet of the container;

a first axial position of the pressure connector where the first prism conduit and second prism conduit are in fluid communication within the structure panel cavity and where an axial face of the pressure connector constrains the clamp in the first position of the clamp;

a second axial position of the pressure connector where the first prism conduit is not in fluid communication within the structure panel cavity with the second prism conduit; and

a second pressure source in fluid communication with the second opening of the first prism conduit; the method further comprising the steps in the order specified:

sterilizing the container, the conduits in fluid communication with the container, the fluid interface, and the first sterilizable tape;

filling the container with sterilized fluid;

configuring the prism to the second axial position, and then inserting the fluid interface into the cavity of the base plate and fixing the structural panel in its first position;

aligning the microreactor device to the heated base plate manifold and fluid interface using an aligner;

contacting the first surface of the first sterilizable tape with the first surface of the second sterilizable tape and then;

simultaneously removing the first and second sterilizable tape;

configuring the clamp in the first position; and

configuring the prism in the first axial position.

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